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JOHN F. KELLY, EDITOR

CONTENTS

Vol. XI. JUNE, 1934 No. VI

A New Technique in Acid Handling—by J. R. Hoover, Asst. Mgr., Chemical Sales Division, The B. F. Goodrich Rubber Company, Akron, Ohio 215

Insulating Firebrick Applications in Steel Heating Furnaces—by M. J. Terman, Refractories Dept., The Babcock & Wilcox Company, Pittsburgh, Pa. 218

Electric Drives For Flying Shears—by L. A. Umansky, Industrial Engineering Dept., General Electric Company, Schenectady, N. Y. 224

Discussion—Electric Drives for Flying Shears—Discussion presented by John C. Reed, Electrical Engineer, Bethlehem Steel Company, Steelton, Pa., and L. A. Umansky, Industrial Engineering Dept., General Electric Company, Schenectady, N. Y. 239

Items of Interest 241

Official Rules and Regulations of A. I. & S. E. E. Iron and Steel Exposition 242

Official Space Application for A. I. & S. E. E. Iron and Steel Exposition 243

The Iron and Steel Industry and Its Relations with Labor ..... II-III

Index to Advertisers IV

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The Iron and Steel Industry

We read with interest much of the propaganda being spread throughout the United States, which pretends to deal with the subject of the Iron and Steel Industry and Its Relations with Labor. Most of the material and data furnished is what might be termed Surface Observations. It is prepared and submitted by persons whose activities in life have never really been in intimate contact with either Labor or the Iron and Steel Industry, by persons whose knowledge of this industry is limited, who could not even with effort distinguish a rolling mill from an open hearth, but yet who speak with apparent authority on matters of which fundamentally they know little about.

The Iron and Steel Industry is not of mushroom growth, it has time behind it, it is perhaps older than any living man, it is at least older than those who attempt to defame it, to tear it down, to question its tradition and its history. Its pages of history are filled with the lives of pioneers who gave much that the Iron and Steel Industry might become a product useful to man.

In its progress the Steel Industry has never failed to recognize its responsibilities to its employees. It has contributed to their social, spiritual and religious welfare. These contributions have been as much a part of the Steel Industry as making Steel itself. It is true that this industry considered men's lives, their ambitions and happiness a part of the steel industries progress. Man's happiness is not concerned with work alone; his social welfare and progress is always an objective and in this ambition the Steel Industry has encouraged its employees not with lip service but with economic support to bring the employees dreams and desires to a successful realization.

Plant Comforts

How does the Steel Industry take care of the man within the plant? Let us start with the man when he leaves his home in the morning—As a rule all steel plants have either underground or overhead entrances carefully protected, he proceeds to his department, hangs his clothes in a modern locker which he alone controls with lock and key. He proceeds to his special location and starts to work.

Every modern device known to man surrounds him to protect him from harm. At lunch time he may visit a plant cafeteria. When his day's work is finished he may if he wishes make use of the modern sanitary equipment—take a bath or a shower. If a man is too warm ventilating and cooling equipment is provided. If a workman wants a cool drink sanitary refrigerating equipment is available for his use. It is not the purpose of this paragraph to indicate the workman leads the "life of Riley" in the steel plant, however, one corporation provided in ten years' time the following:

257 Rest and Waiting Rooms.
160 Playgrounds.
12 Swimming Pools.
106 Athletic Fields.
92 Tennis Courts.
19 Band Stands.
390 Pipe systems for drinking water.
3,604 Drinking Fountains.
739 Wells and Springs protected from pollution.
1,683 Comfort Stations.
8,470 Water Closet Bowls.
3,028 Urinal Bowls.
20,340 Washing Basins.
3,389 Showers.
138,815 Clothes Lockers.
16 Base Hospitals.
396 Emergency Stations.
263 Company Surgeons, Physicians and Internes.
91 Outside Surgeons.
165 Orderlies and other attendants.
77 Visiting Nurses.
250 Teachers and Instructors.

Hospitals

In one of the largest steel centers of the South a steel company erected at a cost of over one million dollars a modern hospital for the use of its employees and their families. One of the notable features of this hospital is that identically the same provisions have been made for the colored as for the white patients.

Sanitation

In Alabama, where a prominent steel company conducts its operations and where climatic conditions are peculiarly favorable to mosquito breeding, this steel company is doing much to prevent the spread of the malaria fever. Streets and alleys are properly drained and pools and lowlands are drained or filled in where practical; otherwise they are covered with crude petroleum. All known methods of fighting the mosquito are employed. Malaria cases in this district have been reduced from approximately 6000 to 200 annually and the comfort of the people in this district has been greatly increased.

Visiting Nurses

Visiting nurses are employed by steel companies in a number of districts. The service is not confined strictly to nursing. The assistance rendered by these nurses is both of professional and practical value. The object of this service is to improve the general health and increase the happiness of the employees and their families. The principal duty of the nurse is to give instructions in those things which will enable the employees and their families to better their condition mentally, physically and materially. Her services are offered free by the company to the employees and their families, but are not forced upon them; she is not permitted to visit the homes of employees upon any occasion unless requested to do so by a member of the family. But opportunities of giving instructions and advice in the matters of household sanitation, economical purchasing of home necessities, care of children—especially in infancy—and the numerous and perplexing problems confronting the mother, are presented through her ability and willingness to help in cases of sickness. Therefore, the nurse must be skilled in her profession, and

and Its Relations With Labor

must also be tactful and of a pleasing personality, so that she will be a welcome visitor in the home, in whatever capacity her presence may be required. Her genuine interest and her desire to be of assistance in time of trouble win the confidence of the people, and she becomes the counsellor, helper and friend from whom they seek aid and advice, knowing that any problem submitted to her will be given careful consideration. The work of these visiting nurses may be briefly outlined as follows:

1. Attending the sick.
2. Giving instruction in personal and domestic hygiene, and domestic science.
3. Helping the families to deal with financial, physical and marital and other domestic troubles.
4. Conduct day nurseries for the purpose of taking care of the children of widows who are obliged to do domestic and other types of work in order to support their families.

Plant Restaurants

Many steel plants operate restaurants for the benefit of its employees, where they are able to secure good, wholesome food at moderate prices. The problem of the "dinner bucket" is solved for the housewife by steel plant restaurants.

Club Houses

Club houses provided by steel plants have provided commodious quarters for the use of their employees, their families and their friends. The features of these clubs include dormitories, reading rooms and libraries, gymnasiums and swimming pools. The affairs of these clubs are handled by the members themselves.

Gardens

Steel plants encourage their employees in garden work. For many years the steel plants have offered special inducements to the employees to utilize vacant land for the raising of vegetables. In the development of community gardens the steel plants plow the grounds at their own expense, plot it out and then offer prizes for the best gardens. The companies render considerable assistance to the employees in the purchase of seeds, garden tools, and other equipment.

Housekeeping Centers

A number of steel plants conduct practical housekeeping centers for special courses in housekeeping which are arranged for the benefit of the wives and the children. Special instructors, usually the visiting or district nurses, are employed for this purpose. Some companies provide houses or special rooms and equipment for the maintenance of this work which includes the preparation and cooking of foods, the care and feeding of babies, dressmaking and many other phases of domestic science, even to the proper method of making beds.

The following are some of the activities carried on at these practical housekeeping centers:

1. Classes for children in sewing, cooking and housekeeping.
2. Meetings for the women of the community for instruction in infant welfare, cooking, sewing, housekeeping, public health and hygiene.
3. A club for the small girls of the community, under the direction of the nurse. These clubs are self-governing, with constitution, by-laws and officers.
4. A club for the boys of the community, under the leadership of a young man, with definite rules covering the conduct, activities and qualifications of the boys for membership. The boys help to formulate these rules and therefore, feel themselves bound to enforce them.
5. A club or association under the direction of the nurse, for women employees of the company, to afford those women employed in domestic service or similar isolated duties, opportunities to mingle socially with the other members of the community.

Playground and Recreation Facilities

The many good results obtained through the establishment and maintenance of playgrounds justify the attempt to provide attractive places for the children and to encourage further efforts in this direction.

In many cases the companies are compelled, because of the immediate needs for playgrounds in certain localities, to utilize whatever ground may be available; thus, a neglected piece of property is cleared of its rubbish and equipped with the more popular playground apparatus, and it immediately becomes an attractive place for children. Many of the playgrounds are located within the plants or works, frequently adjoining the mill yards. Occasionally the playgrounds are turned over to the municipal authorities and are operated by them, the company contributing to the maintenance and upkeep.

Dental Clinics

Dental clinics have been established in many steel districts where steel companies have their operations, and regular hours are designated for the patients. The very best of equipment is in use. A schedule of charges averaging 50% less than the charges made by the city dentists are posted in every dispensary. When an employee or a member of his dependent family applies for treatment at the dispensary his mouth is examined by the dentist and he is given an estimate of the cost of the work required. Payments may be made in monthly installments if the employee so desires.

The dentists in charge of the clinics have been selected with care and are employed on a straight salary basis, their work being under the close supervision of the chief dentist and the superintendent of the health department. The success of this service has exceeded all expectations.

(Please turn to page 223)

INDEX TO ADVERTISERS

A

THE ALLIANCE MACHINE CO. 269
ALLIS-CHALMERS MANUFACTURING COMPANY 262

B

G. H. BALES 254
THE BANTAM BALL BEARING CO. 274
BUSSMANN MFG. COMPANY 245

C

CARNEGIE STEEL COMPANY 260
THE CLEVELAND CRANE & ENGINEERING CO. 258
CUTLER-HAMMER, INC. 246

E

THE ELECTRIC CONTROLLER AND MFG. CO. 265
ELECTRIC SERVICE SUPPLIES CO. 268

F

FARREL-BIRMINGHAM COMPANY, INC. 266

G

GATKE CORPORATION 264
GENERAL ELECTRIC COMPANY 251-255-Cover 4

H

HYATT ROLLER BEARING COMPANY 253

I

I-T-E CIRCUIT BREAKER COMPANY Cover 3

J

JEFFERSON ELECTRIC COMPANY 259

L

LADD EQUIPMENT CO. 254
LEWIS FOUNDRY & MACHINE CO. 257

M

MACKINTOSH-HEMPHILL CO. 252
THE MARTINDALE ELECTRIC CO. 269
McGRAW ELECTRIC CO. 245
McVOY HAUSMAN CO. 254
MESTA MACHINE COMPANY Cover 1
THE MORGAN ENGINEERING COMPANY 273

N

NATIONAL CARBON COMPANY, INC. 250-271
THE NEW DEPARTURE MFG. CO. 249
NEW YORK & NEW JERSEY LUBRICANT CO. 267

O

THE OHIO CARBON COMPANY 267

P

PENNSYLVANIA TRANSFORMER CO. 268
POOLE FOUNDRY & MACHINE CO. 254

R

REITZ SALES CO. 254
RELIANCE ELECTRIC & ENGINEERING CO. 272
ROCKBESTOS PRODUCTS CORPORATION 270

S

SKF INDUSTRIES, INC. 247
STIMPLE & WARD CO., INC. 271
SURFACE COMBUSTION CORPORATION 263

T

THE THOMPSON ELECTRIC CO. 266
THE TIMKEN ROLLER BEARING COMPANY 261
THE TOOL STEEL GEAR & PINION CO. 256
THE TRUMBULL ELECTRIC MFG. CO. 251

U

UNION CARBIDE AND CARBON CORPORATION 250-271

W

THE WELLMAN ENGINEERING CO. 248
WESTINGHOUSE ELECTRIC & MFG. CO. Cover 2

A New Technique In Acid Handling

By J. R. HOOVER
Assistant Manager, Chemical Sales Division,
The B. F. Goodrich Rubber Company,
Akron, Ohio.

Presented before the Combustion Engineering Division of the A. I. & S. E. E. at the Spring Engineering Conference held in Youngstown, Ohio, April 11 and 12, 1934.

Handling acid for pickling has traditionally presented one of the most troublesome, costly and baffling problems of steel plant equipment. Until

J. R. HOOVER

very recently leakage and failure of acid tanks and sewers, rapid corrosion of overhead structures, disintegration of foundations and frequent shutdowns for repair have been taken for granted as an inherent burden of pickling room operation.

Modern trends in steel production, involving huge investments in continuous equipment and smaller margins of profit, have focussed attention on these items of cost as never before. Shutdowns for repair have more far-reaching and costly effects upon plant operation. With heavy continuous equipment the preservation of foundation structures against disintegration by acid becomes vitally important. Of necessity a new technique and a new point of view in acid handling are developing.

The steel engineer of today recognizes that acid leakage and the destructive effects of corrosion must be and can be prevented. A unique and versatile engineering material, rubber, is playing an increasingly important part.

Several fundamental developments necessarily preceded the successful application of rubber linings to pickling tanks and auxiliary acid handling equipment.

The Vulcalock Process

Ten years ago research chemists in the laboratories of the B. F. Goodrich Company discovered a process, known as Vulcalock,[1] whereby rubber and steel can be bonded with adhesion exceeding 500 pounds per square inch. A new material of engineering was thus made available, combining the unique resilience and corrosion resistance of vulcanized rubber with the rigidity and structural strength of steel. A whole new field of usefulness for rubber and steel was opened up. Storage tanks, tank cars, pipe lines, valves and chemical process equipment, fabricated of steel and lined with rubber, presently became standard equipment in handling certain corrosives such as muriatic acid. (Figure 1) Such materials as wood, glass, bitumens, masonry and stoneware were replaced with steel and rubber to great advantage in many industrial applications.

Lining steel equipment by this process is accomplished briefly as follows:

(a) Preparation of the metal surface by sand or grit blasting.

(b) Application of the Vulcalock adhesive. This is an isomeric form of rubber, dissolved in solvent and applied like paint. Several coats are used.

(c) Application of unvulcanized rubber compound in sheet form. The rubber is sticky and semi-plastic at this stage, permitting adjacent sheets to be made integral at the seams.

FIG. 1

(d) Vulcanization of the lining by steam or boiling water. It is during this heating process that the rubber and sulphur combine chemically, changing the compound to the desired form, soft or hard rubber. (Steam pressures of 20 to 60 lbs. per sq. inch are ordinarily used to vulcanize and secure proper adhesion of rubber linings to steel. The

[1] The Vulcalock Process. U. S. Patent Nos. 1605180-1617588.

recent development, however, of hard and soft rubber compounds which can be fully vulcanized at the temperature of boiling water makes possible the lining of large open tanks in the field. There is no size limitation).

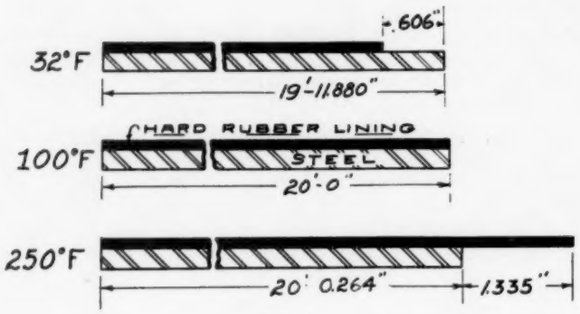


FIG. 2

Soft and Hard Rubber

Rubber lined steel tanks are not new in pickling; but most steel men four years ago had rejected them because of certain basic faults. Existing rubber linings were simply not adapted to the severe conditions encountered.

Hard rubber, best in point of chemical permanence, invariably cracked in service owing to the effects of impact or expansion and contraction with changes in temperature. The co-efficient of linear expansion of rubber within the temperature range 32°-250° F. is approximately five times that of steel. (Figure 2, in showing the relative expansion of rubber and steel, assume the lengths of rubber and steel are the same at 100°F. Also, note difference in lengths at other temperatures.) Even flexible or leathery hard rubber compounds, developed in an effort to overcome this limitation, gradually became weak and brittle when subjected to continued service at pickling temperatures. Cracked hard rubber linings, morevover, were extremely difficult to repair satisfactorily.

Soft rubber readily absorbed the strains incident to expansion and contraction, but was too easily cut and gouged by heavy metal parts. Soft rubber, too, lacked the resistance of hard rubber to oxidation and to the penetration of hot acid, oils and vapor.

A further defect in many of the rubber lined tanks which had been tried in pickling was poor adhesion between lining and steel. Blisters formed and failure soon followed. Accidental puncture of a poorly adhered lining often permitted acid to creep between the lining and the steel, causing extensive damage to the tank before the original point of rupture was discovered. (Also a familiar defect in lead lined tanks).

Fortunately, the problem of integral adhesion had already been solved by the discovery of the Vulcalock process. In case of accidental puncture, the Vulcalock bond, in itself acidproof, allowed no seepage between rubber lining and steel tank.

With the successful application of this process as a background, our engineers turned to the job of designing a lining which would combine the merits of hard and soft rubber and eliminate the apparent weaknesses of each.

Triflex

The result was Triflex,[2] a distinctly new form of rubber lining, comprising a layer of true hard rubber (ebonite) cushioned between two layers of resilient soft rubber, all three plies being vulcanized together to form an integral structure. The resistance of hard rubber to chemical and solvent action, diffusion and absorption was combined with the resilience of soft rubber; at the same time yielding a structure of greatly improved resistance to impact, cutting and gouging. Repairs, if necessary were easily made.

Adequate provision was made for expansion and contraction with changes in temperature. The plies of hard rubber in adjacent sheets of Triflex were overlapped in such a manner that they floated in soft rubber, free to come and go without distortion or cracking as heat conditions changed. (Figure 3).

Bonded to steel by the Vulcalock process, the new three-ply lining with expansion joints was a fundamental advance in rubber lining. It is being

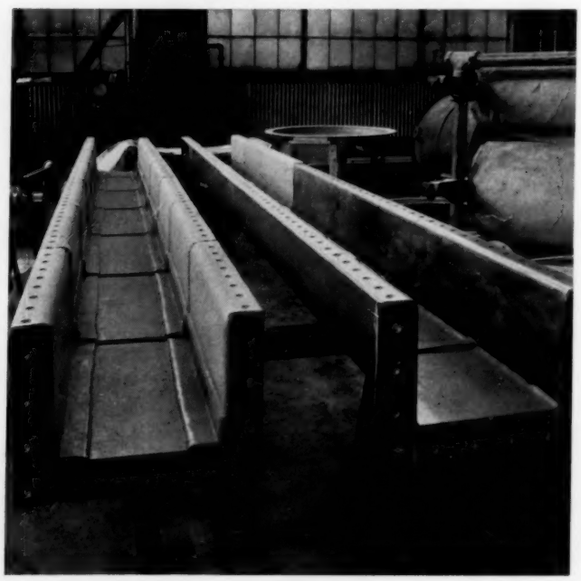


FIG. 3

successfully applied in the construction of acid fume ducts, tank covers, exhause fans, acid sewers, storage tanks and electroplating tanks.

None of this equipment, however, undergoes the severe mechanical abuse to which pickling tanks are subjected. If the new lining was to be successfully used in steel pickling tanks it had to be protected in some manner from accidental violent contact with cradles, chains, or the steel being pickled.

Brick Sheathings

Brick, because of its known chemical permanence, physical strength and low cost, was the logical material to choose for this part of the tank structure.

[2] Triflex, U. S. Patent No. 1919366. Triflex linings can be applied by the Vulcalock process to large open tanks in the field and vulcanized in boiling water with adhesion to steel of not less than 500 pounds per square inch.

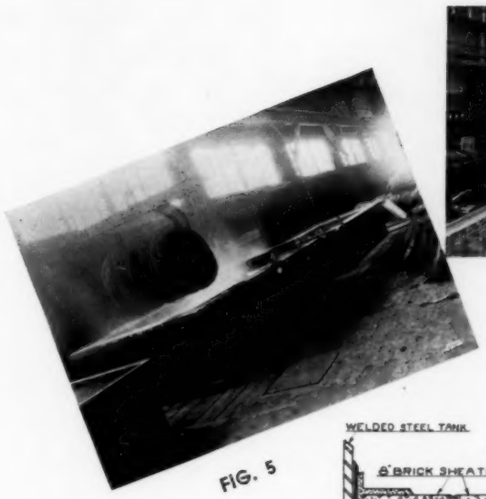


FIG. 5

FIG. 6

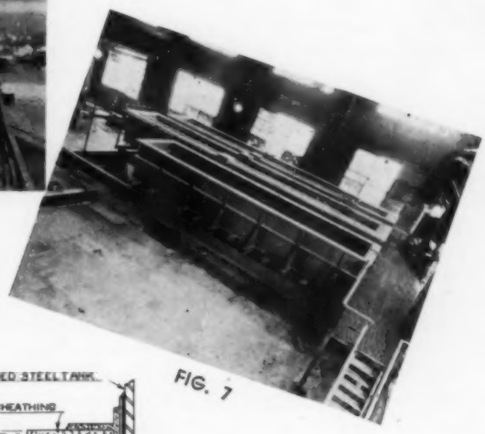


FIG. 7

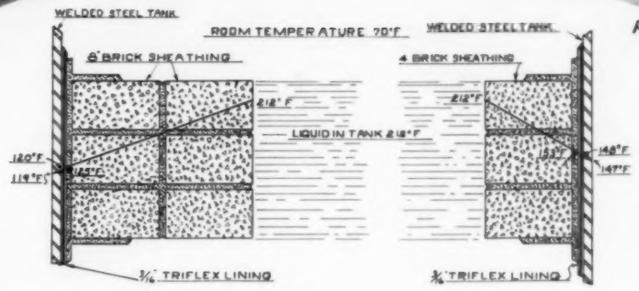


FIG. 4

In addition to insuring freedom from mechanical damage to the rubber lining, brick sheathings were found to have the further merit of substantially reducing the temperature at the rubber surface. This was of fundamental importance. At high temperatures the useful life of any rubber lining will be shortened owing to the effects of more rapid diffusion and oxidation. The best ultimate economy is obtained by reducing the temperature at the rubber surface to 150° F. or less whenever possible.

The temperature reductions to be expected through single and double sheathings under conditions of normal room temperature and free circulation of air outside the tank are indicated by Figure 4. The insulating effect persists in spite of small cracks at the joints or seepage through the brick,—and serves materially to increase the useful life of the rubber lining. Extremely large cracks which allow rapid convection currents of hot liquid to circulate in contact with the rubber lining are, of course, to be avoided in the interests of maximum service life. The thermal insulating value of brick sheathings depends upon a stationary column of liquid rather than a flowing column being maintained in contact with the lining. Reasonably free circulation of air around the outside of the tank is necessary in order to obtain the maximum reduction in temperature.

In deciding whether a single or double brick sheathing should be installed the nature and concentration of acids handled, operating temperature, room conditions and severity of physical abuse must all be taken into consideration.

Through the co-operation of engineers in the field of ceramics and jointing materials, a thorough, systematic study was made of materials and methods.

Acid-resisting shale brick of common size, wire cut and well vitrified, were found generally best suited for this work owing to their good adhesion to jointing materials, excellent physical properties, and low cost.

Bonding agents for the brick were chosen with respect to adhesion, strength of material (especially as regards impact), resistance to chemical action and steam, ease of application and cost. Although of somewhat higher cost than other types, sulphur-base jointing compounds when properly applied are usually the most economical over a period of years, owing to their superior durability in rough service. This applies especially to large tanks.

Sulphur-base compounds are melted and poured into the joints at a temperature of approximately 250° F. A very satisfactory method of construction has been developed and patented, involving the use of special rubber expansion joints in the brick walls and base, which relieve the complete structure from serious strains due to changes in temperature.

Installations

The essential features of an acid pickling tank appeared to be combined in this new steel-Triflex-brick design. During the past four years much valuable data and experience have been accumulated based upon actual installations. Tanks have been used, watched and constructively criticized. Details of construction have been developed. Engineers and operating men of the steel industry have co-operated in establishing the proper design of welded tank and in furnishing a proving ground of actual service.

Flange design and protection, structural reinforcement, methods of support, outlets and syphons,—all were studied and improved.

Practical results speak for themselves. More than a hundred tanks of this new design have been installed during the past four years All are in active service today. None have developed leaks or structural defects. In most plants they have earned their cost within the first year or two of operation. (For typical installation, see Figure 5).

There has been a growing confidence among steel men that the wastes imposed by leaking tanks, corrosion and shutdowns for repair are **definitely avoidable.** This is the new point of view in acid handling. A new technique is developing, in which the rubber industry is proud to have a share.

Two of the largest continuous strip mills in the United States are equipped with the new acid tanks, —a total of eleven 60-foot tanks in this service. In one of these mills the tank covers, fume exhaust system and acid sewers are all of rubber lined steel construction. (Figure 6.)

Sizes of tanks in other plants range from small containers for pickling stampings and forgings to a tank fourteen feet wide, ninety feet long and eight feet deep for the continuous pickling of large sheets. Long, heavy billets are being pickled, twenty tons per load, in two forty-five foot tanks installed during the summer of 1933. (Figure 7.)

In every case maintenance work on the tanks has consisted simply in the periodic application of acid-resisting paint to the exterior. Heat from the bath within keeps the outside steel surface dry, minimizing corrosion.

Steel, rubber and brick, three widely different materials of construction, each designed to perform definite functions in the whole tank structure, combine to achieve these results. Pickling costs have been substantially reduced, working conditions improved; and a new market for steel opened up—objectives gained simply through the intelligent co-operation of far-sighted engineers and operating men who refused to be satisfied with wasteful methods.

Insulating Firebrick Applications In Steel Heating Furnaces

By M. J. TERMAN
Refractories Dept., The Babcock & Wilcox Company, Pittsburgh, Pa.

Presented before the Combustion Engineering Division of the A. I. & S. E. E. at the Spring Engineering Conference held in Youngstown, Ohio, April 11 and 12, 1934.

M. J. TERMAN

Increasing demands for lower manufacturing costs, during the past four years, have led to a broadening of the applications of insulating firebrick in steel heating furnaces. Inasmuch as fuel is one of the major items of cost in the production of steel, careful attention has been focused on the economical utilization of fuels.

Although substantial progress has been made in furnace design, temperature and atmosphere control, burner improvements, and refinements in mechanical handling, less attention has been given to furnace linings in the past, except from the standpoint of obtaining longer life. In the construction of steel heating furnaces it has been common practice to use low and intermediate temperature insulating materials for backing up fireclay brick linings; however, the primary consideration in the use of these products has been that of reducing losses by conduction through and radiation from the furnace structure.

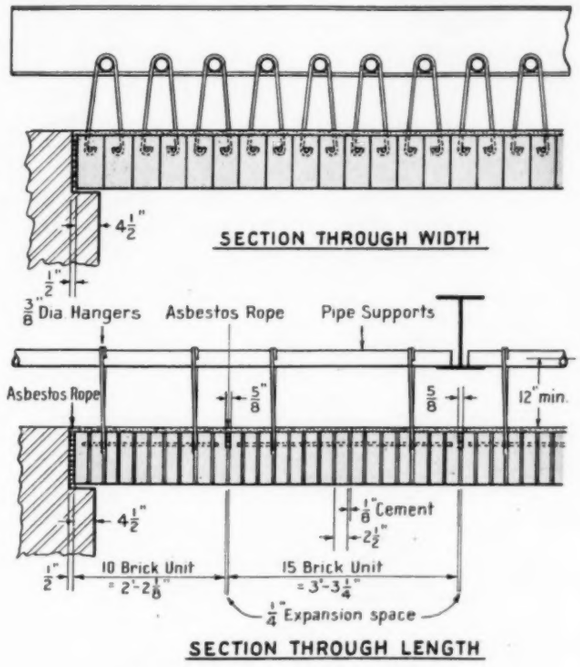
In recent years research and development work have made available light-weight refractory materials which possess, in addition to high insulating value, the qualities of refractoriness and mechanical stability making them suitable for use directly exposed to the furnace at elevated temperatures. These materials are commonly known as insulating firebrick. Insulating firebrick for high temperature applications are recent newcomers to the steel industry, although semi-refractory insulators have been in use for years as backing-up materials and as direct linings in electric heating and other low temperature installations.

In this paper, for the purpose of brevity, only insulating firebrick of the alumina-silica type will be discussed.

A very important characteristic of insulating firebrick is lightness in weight, because the thermal capacity is proportional to the weight, and low thermal capacity is valuable in effecting time and fuel savings.

Likewise it is important that insulating firebrick have the characteristic of low thermal conductivity,

particularly at high temperatures. The thermal conductivity at low temperatures is not of great importance as many satisfactory low temperature insulating materials are available.



Insulating Firebrick Suspended Arch.

In regard to spalling resistance, research studies, correlated with field observations, indicate that the characteristics of low thermal expansion and freedom from shrinkage are essential—the former being dependent on selection of raw materials and the latter on burning initially at temperatures higher than those encountered in service.

As heavy refractories have been used many years for standard furnace lining materials there is skepticism in the minds of some engineers regarding the serviceability of light-weight materials exposed directly to flame conditions. Service results covering the past three years prove that high-fired insulating firebrick, ranging in weight from 30 to 39 lbs. per cu. ft. have ample strength for use in walls and sprung arches of reasonable height and span. As the material is light in weight the wall height can be made as high as with fireclay brick, as the insulating firebrick when heated, has a load-carrying capacity in proportion to its weight. Sprung arches 9" thick, with spans up to 15'6" have been in service over two and a half years. With operating temperatures of 2650-2750 deg. F., the spans of insulating firebrick arches are usually limited to 12 or 13 ft. in order to provide a factor of safety in event of overheating.

In certain types of furnaces, suspended arches are preferable to sprung arches and in these instances insulating firebrick have been used in special or conventional suspended arch designs. Insulating firebrick are of especial advantage in suspended arch constructions as the suspending members may be light and inexpensive, the total weight being about one-quarter of that of a firebrick arch of conventional design including castings and supporting steel. In addition, the fact that a material of low thermal conductivity is placed between the surface exposed to the furnace and the supporting members, reduces the possibility of burning the latter and also materially reduces the heat conducted through the arch.

As insulating firebrick, in comparison with fireclay brick, do not have the necessary properties to withstand constant mechanical abrasion, heavy superimposed loads, slagging conditions, and various types of mechanical abuse, it is necessary to provide adequate protection for areas where these conditions are encountered. Recognition of the physical and chemical limitations of insulating firebrick will greatly assist in the correct use and in the prevention of misapplications.

In the discussion of advantages and savings to be gained by using insulating firebrick instead of fireclay brick, the author wishes to point out that the following data and information partially covers the history of a light-weight, high-fired, kaolin product. Although the majority of installations involve only the substitution of an equal thickness of insulating firebrick, mention should be made that, on several jobs, changes have been made in burner capacity, hearth area, change of fuel, and reduction in the thickness of linings. However, these changes on a comparatively small number of furnaces do not materially affect the composite picture.

By using insulating firebrick instead of fireclay brick, the time saved in heating a furnace to operating temperature is a valuable item. This saving, on a cold start, ranges from 25% to 85% depending on size and type of furnace, temperature limitations on rate of heating stock, burner capacity, and temperature control. With small batch type furnaces, operating on a seven to ten hour day schedule with fuel cut off over night, the time saving in heating up varies from 40% to 85%. The fuel savings dur-

Car Type Annealing Furnace at the Babcock & Wilcox Tube Co.
4½" Insulating Firebrick Lining

ing the heating-up period are directly proportional to the time savings.

The economic importance of these savings expressed in terms of heat flow and heat capacity, may be illustrated by two batch type furnaces with linings of equal heat flow; one furnace is lined with 9" fireclay brick backed up with 4½" insulating brick and 1" of block insulation—the other with 9" of a commercial insulating firebrick. The comparative weights of these linings, per sq. ft., of component wall section, are 110 lbs. and 26 lbs. respectively. For an operating temperature of 2500 deg. F., the fireclay brick lined furnace, at thermal equilibrium, has a thermal capacity of 55,000 B.t.u. per sq. ft., as compared to 7750 B.t.u. per sq. ft., of the insulating firebrick lining. It is obvious that not all of the heat supplied to the furnace is available for heating the linings, as a part is lost in the flue gases. As the flue gas temperature of these two furnaces is the same as the furnace temperature, approximately 66% is lost in the flue gases. Thus, the total amount of heat supplied to each square foot at thermal equilibrium is 162,000 B.t.u. and 22,800 B.t.u. respectively.

The overall fuel savings for an insulating firebrick lined furnace, as compared with a furnace lined with fireclay brick or a combination of fireclay brick backed up with insulation are dependent on the length of cycle, duration of shutdown, operating temperatures—which in turn determine the differences of heat flow and thermal capacity of the two linings. As a general rule, the shorter the cycle the greater is the fuel saving. However, in so-called continuous furnaces which shut down over the week-end, fuel savings alone are sufficient to compensate for the extra cost of insulating firebrick in six to fifteen months, depending, of course, on fuel cost, operating temperatures, and cost of materials.

Furnaces lined with insulating firebrick have a more even distribution of temperature throughout than fireclay brick lined furnaces. This difference is very noticeable in furnaces having a 4½" or 9" lin-

HEAT FLOW OF WALLS AT THERMAL EQUILIBRIUM

B. T. U. PER SQ. FT. PER HOUR

Wall No.	Thickness in Inches				Hot Face Temperature, deg. fahr.								
	B. & W. Insulating Firebrick	Fire Clay Brick	Calcined Diatomaceous Insulator	Insulating Block	1200	1400	1600	1800	2000	2200	2400	2600	2800
1	4½				380	490	610	730	860	1005	1170	1350	1550
2	9				190	250	310	375	450	525	610	695	790
3	13½				120	170	215	260	315	365	420	480	545
4	4½			1	315	375	435	495	560	620	685	755	
5	9			1	170	200	235	270	305	340	380	425	470
6	4½			2	175	225	275	330	390				
7	9			2	120	155	190	230	275	320	370		
8	4½	9			235	290	355	435	525	620	730	850	970
9	9	4½			190	210	240	280	340	400	470	555	650
10		9			680	855	1050	1250	1465	1700	1955	2215	2485
11		13½			550	655	775	910	1060	1225	1400	1590	1790
12		18			400	500	605	715	830	950	1075	1210	1340
13		9	4½		240	320	400	480	570	660	750	840	940
14		13½	4½		195	265	340	420	500	580	660	740	830

TABLE I

HEAT CAPACITY OF WALLS AT THERMAL EQUILIBRIUM

B. T. U. PER SQ. FT.

Wall No.	Thickness in Inches				Hot Face Temperature, deg. fahr.								
	B. & W. Insulating Firebrick	Fire Clay Brick	Calcined Diatomaceous Insulator	Insulating Block	1200	1400	1600	1800	2000	2200	2400	2600	2800
1	4½				1,750	2,100	2,450	2,800	3,100	3,450	3,800	4,150	4,500
2	9				3,500	4,150	4,800	5,450	6,100	6,750	7,400	8,100	8,750
3	13½				5,500	6,450	7,350	8,300	9,250	10,200	11,100	12,100	13,000
4	4½			1	2,100	2,600	3,100	3,650	4,200	4,700	5,200	5,750	
5	9			1	4,500	5,200	5,900	6,600	7,300	8,000	8,700	9,400	10,100
6	4½			2	2,750	3,250	3,750	4,250	4,750				
7	9			2	5,000	5,800	6,650	7,500	8,350	9,200	10,000		
8	4½	9			9,400	11,200	12,800	14,400	16,000	17,700	19,200	20,800	22,500
9	9	4½			6,200	7,250	8,250	9,250	10,300	11,300	12,250	13,250	14,300
10		9			17,000	19,500	22,500	25,000	28,000	31,000	33,500	36,500	39,500
11		13½			25,000	29,500	33,500	38,000	42,000	46,000	50,000	54,500	58,500
12		18			32,500	38,000	43,000	48,500	54,000	59,000	64,500	70,000	75,000
13		9	4½		28,000	32,500	37,500	42,000	47,000	52,000	56,500	61,500	66,000
14		13½	4½		39,000	45,500	52,000	59,000	65,000	72,000	78,500	85,000	91,500

TABLE II

ing. Even temperature distribution results in uniform heating, with an improvement in quality of product.

Because of low thermal capacity, a furnace lined with insulating firebrick is very sensitive to temperature control. This is advantageous for a closely controlled cycle, either on heating or cooling. Low thermal capacity of linings, is valuable in continuous furnaces heating various types of steel, which necessitates a raising or lowering of temperature, with a corresponding mill delay. In several instances, the time in making such adjustments of temperature in insulating firebrick lined furnaces ranged from 25 to 40% of the usual time required for these changes.

Insulating firebrick also offer the advantage of decreasing the space requirements of a new furnace. As few furnaces require more than a 9" insulating firebrick lining, the saving in overall width of a furnace (assuming equal hearth areas) ranges between 9" and 18", depending on the thickness of fireclay brick walls customarily used. Likewise in existing furnaces an increase in hearth area can be obtained by reducing wall thickness. An example of this is the reduction of wall thicknesses in box annealing furnaces to accommodate wider boxes—by passing a part of the expense of completely rebuilding present units.

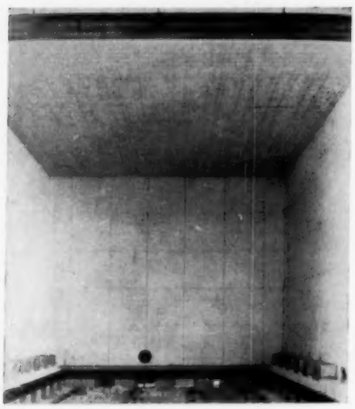
A comparison of heat flow and heat capacity data in tables I and II shows that as the heat flow of fireclay brick combinations is decreased (by increasing the lining thickness) the heat capacity increases. The obvious reason for this is the increase of the mean temperatures of the materials in the wall.

A comparison of a 9" insulating firebrick wall with fireclay brick combinations is given in Fig. 1.

Comparison of Heat Flow and Heat Capacity of Walls. Using 9" Insulating Firebrick as Standard, Hot Face Temperature 2400 deg. F.

Walls	Heat Flow Ratio	Heat Capacity Ratio
9" Insulating Firebrick plus 4½" Cal. Diatomaceous Ins.	0.64:1	1.48:1
9" Fireclay brick	3.21:1	4.52:1
13½" Fireclay brick	2.30:1	6.76:1
18" Fireclay brick	1.76:1	8.71:1
9" Fireclay brick plus 4½" Cal. Diatomaceous Ins.	1.23:1	7.64:1
13½" Fireclay brick plus 4½" Cal. Diatomaceous Ins.	1.08:1	10.6:1

FIG. 1.



Stress Relieving furnace at Boulder Canyon Works of the Babcock & Wilcox Co. Inside Dimensions 36' x 41' x 29' high from car top.

In presenting operating data on the following insulating firebrick lined furnaces, there is no intent to infer that total savings on all the jobs reported should be credited to change of linings. Other known factors having a direct bearing on savings will be given.

It is hoped, however, that the information presented will serve as a guide for evaluating some of the outstanding benefits to be derived from the use of insulating firebrick in steel heating furnaces.

Car Type Tube Annealing Furnaces

Two car type tube annealing furnaces fired with natural gas, are used for annealing numerous alloys and plain carbon steels. Maximum temperature is 1700° F. The longest cycle covers heating 6 to 8 hours, to 1700° F., and cooling 8 to 10 hours to 1200 deg. F. One furnace 42 ft. long is lined with 6" fireclay brick backed up with 4½" insulating brick; the other, 71 ft. long, is lined with 4½" insulating firebrick. The combustion volumes of the two furnaces are 1,400 cu. ft. and 910 cu. ft. respectively. The 71 ft. furnace is equipped with 154 high pressure two-stage velocity burners with maximum capacity of 9548 cu. ft. per hour. The 42 ft. furnace is equipped with 55 of the same type of burners with a maximum capacity of 5,610 cu. ft.; burner capacity in terms of 1,000 Btu. natural gas at 20# pressure.

The following data covers the same length of cycle and the same metal:

Furnace Lined with 4½" Insulating Firebrick		Furnace lined with 6" Fireclay Brick plus 4½" Insulating Firebrick	
Loading #/sq. ft.	Fuel Consumed Cu. ft. gas/#metal	Loading #/sq. ft.	Fuel Consumed Cu. ft. gas/#metal
138	1.97	134	2.33
154	1.99	166	2.65

The above fuel savings are 15.5% and 24.9%. With adequate loading the average savings are approximately 25%.

Another typical example of fuel savings, made possible by changing from fireclay brick linings to light weight insulating firebrick of equal thickness, is reported by a small commercial forging shop using natural gas, having three slot type heating and one solid hearth forging furnaces. The change in linings was made the last week in November, 1933. At this time automatic temperature control was installed on the forging furnace. The monthly tonnages during December, 1933, January, 1934, and February, 1934, were approximately the same as the average monthly tonnage from January to November, 1933, inclusive. Gas bills for the four furnaces were:

Average Jan.—Nov. 133	$166/Month
Dec. 1933	106 "
Jan. 1934	108 "
Feb. 1934	100 "
Average Fuel savings	36.9%

Comparison of Performance of Insulating Firebrick of different weights—slot type heating furnace

Operating Temperature	2100°F.
Burner Equipment	Same for both furnaces
Fuel—Manufactured Gas	550 B.t.u./cu. ft.

Size—Hearth 12"x40"—Walls 13½" high—Slot 3"x40"

Construction—Same for both furnaces

Sidewalls and Endwalls 4½"
Roofs 9"

Bottoms 1" plastic chrome plus 6½" fireclay brick plus 2½" insulating firebrick.

No. 1 furnace lined with Brand "A" Insulating Firebrick (30#/.cu. ft.)

No. 2 furnace lined with Brand "B" Insulating Firebrick (47.5#/cu. ft.)

	No. 1 Furnace	No. 2 Furnace
Stock ½x7/16x6"	1.296#	1.296#
Time from lighting until ready for work	21 min.	36 min.
Gas used for heating up	244 cu. ft.	438 cu. ft.
Total Cycle including heating up	8 hr.	8 hr.
Total gas consumption /8 hr. cycle	5095 cu. ft.	6087 cu. ft.
Total number of pieces heated	1600	1320
Total weight of stock heated	2073#	1710#
Pieces per hour	200	165
Cu. ft. gas/lb. steel heated	2.46	3.56
Percent Savings		
In time to heat up	41.7	
In fuel to heat up	44.3	
In fuel per lb. of stock heated	30.9	
Per cent increase in prod.	21.2	

The economic thickness of an insulating firebrick in comparison with other lining materials is that which will produce maximum saving with the minimum overall cost. For a complete analysis of the

Stress relieving furnace at Boulder Canyon Works of the Babcock & Wilcox Co. Furnace walls are 4½" and roof 9" of Insulating Firebrick.

problem, it is necessary to have reliable information and data, which can be used to predict, for any heating cycle, the results that will follow the use of a given amount of a given insulating firebrick under given conditions. Such information and data is available.

In closing we would remind you that insulating firebrick have a definite history of satisfactory use—this statement being based on service records of more than a thousand installations in various types of heating furnaces.

Progressive executives and engineers are to be commended for the encouragement and co-operation they have given in pioneering the use of this material.

Large Heat Treating Furnace. Inside Dimensions 32'-6" x 5' x 2'6" High. Oil Fired. 9" Insulating Firebrick Lining.

THE IRON AND STEEL INDUSTRY AND ITS RELATIONS WITH LABOR

(Continued from page III)

Education

For many years steel companies have been carrying on educational programs among their employees, including vocational training and apprenticeship classes. The purposes are:

To increase the efficiency of the workmen by teaching the fundamental and the more advanced principles involved in their individual lines of work. To increase the earning power of the pupils by guiding them along the paths of quicker and deeper reasoning which lead to positions of gradually increasing responsibility in all departments of the mill. To promote and develop the happiness of the pupils not only in their daily work in the shops and mills, but in their home life as well by opening the door to a more thorough understanding of the meaning of life and work.

Homes

Many steel plants have made it possible for the employees to finance and erect a home. One steel corporation has made it possible for almost 30,000 employees to finance their own homes.

Group Insurance

In one steel plant employing 3600 men the Group Insurance Plan was started June 15, 1926. From that date until June 12, 1934, a total of $777,000 has been paid in claims. Those who received this insurance had outside insurance in force amounting to $253,840. Of the $777,000 paid, $265,622 was paid to those who had no other insurance.

Welfare

One of the largest corporations in ten years paid out $85,000,000 for welfare work.

Conclusion

In the above, where no effort has been made to outline in a detailed manner, but rather in a random fashion, it can be seen that the Steel Industry has never failed to render invaluable aid to its employees. As a challenge, what village, borough, town or city, where steel plants are located, has ever failed to secure the aid of the Steel Industry in public or community movements for churches, schools, clubs, housekeeping centers, swimming pools, athletic fields, recreational centers and libraries. With such an enviable record of achievement, the Steel Industry stands today ready and willing to further its splendid relations with its employees and the community.

Reduced round-trip R. R. rates for the 1934 A. I. & S. E. E. CONVENTION AND IRON AND STEEL EXPOSITION

Cleveland, O., Sept. 18, 19, 20, 1934

(Identification Certificate Plan)

On account of our Annual Convention and Iron and Steel Exposition to be held in Cleveland, O. next September, we have been granted a one and one-third round trip railroad rate (with minimum of $1.00) through use of the Identification Certificate Plan. This low rate applies on round-trip tickets via the same route on both going and returning trips and if a diverse route is used on the return trip there is only a slightly higher tariff applying, however full information can be given you by your local ticket agent who has a complete file of these tariffs, etc. This low rate applies to nearly every railroad of the United States, also to the principal Canadian points.

From most points, tickets will be on sale from Sept. 14th to Sept. 18th for the going trip, however from far distant points the sale starts one day earlier. **These tickets are good for thirty days from date of sale** (including day of sale) and must be validated at the regular ticket office in Cleveland, O. before they can be honored for return passage; this validation begins on Sept. 18 1934 but the return trip may start from Cleveland on any day within the final limit of the ticket. The return trip must be completed by midnight of the date of the expiration of the ticket.

Only ONE Identification Certificate is needed for each one eligible as this Certificate will also take care of the dependent members of his or her family, however the Certificate must be presented and surrendered to your ticket agent when you purchase the round-trip ticket at this reduced rate.

We will send out these Certificates at a later date, however if you wish to make sure of your supply kindly drop us a line and at the proper time we will be glad to mail them to you. In event you desire several Certificates please let us know and we will take care of your requirements when these are distributed.

Electric Drives For Flying Shears

By L. A. UMANSKY
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Presented before the Philadelphia Section of the A. I. & S. E. E. on December 2, 1933, and before the Pittsburgh Section of the A. I. & S. E. E. on December 16, 1933.

FOREWORD

The modern trend in industry is definitely toward the continuous process. Each successive step in this process should harmonize with others in speed of performance, in order not to become "a weak link in the chain."

L. A. UMANSKY

Many up-to-date rolling mills are turning out material at a rate of several hundreds or even several thousands of feet per minute. The finished length of the stock runs also into hundreds or thousands of feet; the longer is this stock, the lower is the waste of material due to cropping, the more efficient becomes the mill. The handling of this material, as it is delivered from the finishing stand, often becomes as much of a problem as the design of the mill itself.

When the stock is sufficiently thin to be coiled or reeled, and when such handling of material is otherwise feasible, then it is usually resorted to. Suitable coilers or reels are set within a reasonable distance from the mill and wind the material as it is being delivered. The whole layout is compact and satisfactory.

Heavier sections cannot be readily coiled. Many others should maintain their straight-line form for other reasons. The handling of a bar, say, a thousand feet long, without cutting it into shorter lengths, is seldom feasible, the space requirements forming the obvious objection.

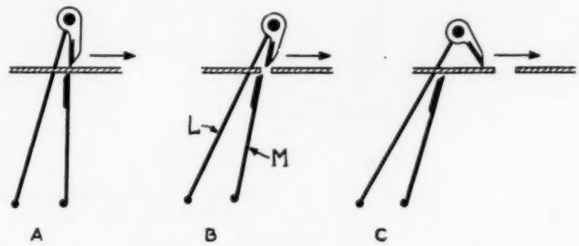

FIG. 1—Elementary Diagram of Edwards' Steam Operated Flying Shear.

Thus the problem becomes one of cutting the material "on the fly", as it comes from the mill. This "flying shear" cutting becomes a requisite of most all up-to-date mills, whenever coiling is out of question.

The term "flying shear" is also applicable, of course, to any shear cutting the moving material, even though the material is free from the mill. While the mechanical parts of shears may not differ much in either case, the problem of selecting the suitable electrical equipment is immensely more involved when the metal is sheared being simultaneously in the mill and the shear. This explains why the greater portion of this paper deals with equipments of the latter kind.

STEAM DRIVEN FLYING SHEAR

The first successful flying shear, designed by V. E. Edwards, was steam operated. Its operating principle is illustrated on the diagram, Fig. 1.

In position (a) the upper and lower blades are so set that the bar passes freely between them. When the front end strikes the flag (not shown), set a certain distance behind the shear, the flag trips open the valve of the operating steam cylinder (not shown) which causes the levers L and M, together with the knife blades, to accelerate in the direction indicated by the arrow and to come together shearing the metal. In position (b) the knives have just cut the bar; the blade speed, while cutting, matches the speed of the metal. After the cut, the upper blade swings out of the way of the moving bar (see position c) and the return stroke of the piston bring the shear back to its original position (a).

The shear runout table is usually set to run somewhat faster than the mill delivery speed. Thus the gap between two consecutive cuts is gradually growing; this permits the flag to drop to its original position, ready to be tripped again by the coming front end of the next piece to be cut off.

In order to crop the front end of the bar, the shear is tripped by the operator. The latter uses his eye and judgment to trip the shear just at the proper instant, so as to get the desired length of crop. Few difficulties, if any, are usually experienced in this respect.

By moving the flag switch away from the shear, the length of cut is obviously increased. This gives

a ready means of adjustments, which means are quite accurate, provided the time elapsed from the tripping of the flag to the actual cut is always the same. The consistency of this element of time depends, of course, on steam pressure and other like factors.

These steam flying shears were in use for a number of years. They made possible the advent of the continuous billet and bar mills and certainly constitute an outstanding landmark in the art of rolling. Their accuracy is considered quite sufficient for cutting billets and bars into commercial lengths; it is understood that a tolerance of, say, 1" or 2" on a 30 ft. length is obtainable, provided the steam pressure is maintained constant. This result is truly remarkable, if one stops to consider that with a delivery speed of only 600 FPM, and 20 ft. cuts, the shear must start and stop 30 times a minute; each time the heavy reciprocating parts must be accelerated to full speed and must then be retarded and stopped, all in 2 seconds or less; it is also understood that

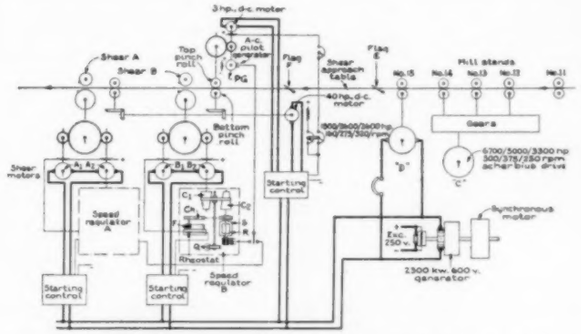

FIG. 2—Mill Layout and Shear Control at the 27"-24"-21" Sheet Bar and Skelp Mill, Bethlehem Steel Co., Sparrows Point, Md.

this speed of operations is not considered as an upper limit for steam flying shears.

But neither are the steam shears without their shortcomings. A reciprocating steam engine, operating under such trying conditions, is bound to have relatively high maintenance costs. Steam is not always available where the shear is to be installed; a long steam line or a separate boiler plant—particularly the latter—are costly. Compressed air has been considered more than once; but then the first cost and the maintenance cost of the compressor plant (or of an enlargement of the existing one) should be charged against the flying shear.

This constitutes the necessary background, both economic and engineering, for bringing into the picture the electric drive. If electric power, without which the steel industry could not be what it is today,—has altered the face and substance of the rolling mills, why not apply it to the flying shears?

GENERAL PRINCIPLES OF ELECTRIC SHEAR DRIVES

It is out of question, practically speaking, to design and build an electrically-driven flying shear of the same type as the Edwards' steam shear, i.e. to start and stop for each cut, to do so 30-50 times a minute or more, and to cut the metal with the desired accuracy.

The shear parts, in order to be of the needed ruggedness, should of necessity possess a substantial inertia. To accelerate and then to bring to rest this mass, in the short time available, a large volume of power should be brought into play. A driving motor, required to develop this power even momentarily, should be of very large continuous capacity; with the best design possible, such motor would have a very appreciable inertia of its own; this increases the required capacity still further. The problem becomes one of "lifting oneself by the bootstraps."

Broadly speaking, a flywheel could be employed as an "energy storage tank." The motor with its flywheel could then be running continuously, and the shear proper would be started and stopped for each cut by means of a clutch, very much as is done as yet on many stationary shears.

But who would like to have and to maintain such a clutch for a flying shear of any magnitude, operating with the frequency which is considered here?

Thus, by the process of elimination, an electrically driven flying shear as now known to the art has taken the form of one or more rotating knives, going through a definite cycle, and encountering and cutting the metal at a definite point in this cycle. The speed of the knives has a definite relation to the speed of the metal; this relation determines the length of metal passing through the shear from cut to cut, i.e., determines the length of cut.

This immediately brings into the picture a synchronizing device or devices, arranged to keep the shear speed in proper step with the delivery speed of the metal. This is THE FIRST fundamental problem to be solved. A good deal of effort and brain power has been spent on it and, we can state without hesitation, that a great deal more must be spent before a truly 100% solution for all cases is found.

A continuously rotating shear will crop the approaching bar at almost any distance of the front end; if the length of cut is, say, 30 ft., then the shear may crop 6 inches at one time or 29 ft. 6 in. at some other time; by the law of averages the crop is apt to be about 15 ft. long, while 6 or 8 inches is usually ample. Now if the whole bar is 500 ft. long, the loss due to such excessive cropping is about 3% and should not be tolerated.

Thus it becomes imperative not only to synchronize the speed of the shear with that of the metal, as needed for accurate cutting, but also to fix the position of the shear knives when the front end of the approaching bar reaches a definite position. This is the SECOND vital problem to be solved.

It is interesting to observe on specific cases how these problems were practically solved, what operating results have been obtained, and what improvements are yet possible.

BAR AND SKELP MILL SHEAR

General Layout

A 27-24-21" continuous mill was built in 1926 for the Sparrows Point Plant of The Bethlehem Steel Co. The original layout is diagrammatically shown on the Fig. 2.

The mill is arranged to roll either sheet bar or heavy skelp (without reheating after the blooming mill). Depending on the weight of bar, the rolling is completed on any one of the stands 12-13-14 or 15. (Later on, the stand 15 was moved elsewhere,

but as the shear equipment was laid out considering this stand, the latter will be left in this description, as if it were maintained).

The stands 12-13-14 are jointly driven by a 6700/-5000/3300 HP—500/375/250 RPM Scherbius equipment, known as the drive "C". The stand 15 is individually driven by the D.C. motor "D", rated 2600 HP—275/320 RPM—600 V; this motor is furnished with power from a 2300 KW, 600 V D.C. generator, and a motor speed range down to 160 RPM was provided by generator voltage control.

The shear equipment was arranged for a delivery speed of substantially over 1000 FPM. The sheet bars are cut into various lengths, averaging about 30 ft.; the skelp is cut into shorter lengths (average —20 ft.). It was deemed advisable by the mill designers to furnish two separate flying shears, A and B, to cut the sheet bar and skelp respectively. Both shears are identical in design, except for a difference in some gear ratios. Electric drives are duplicates. Hence only one will be described.

Shears

Fig. 3 shows diagrammatically the sheet bar shear. Its two drums, "X" and "Y", are each carrying a knife blade. The bar passes between these drums.

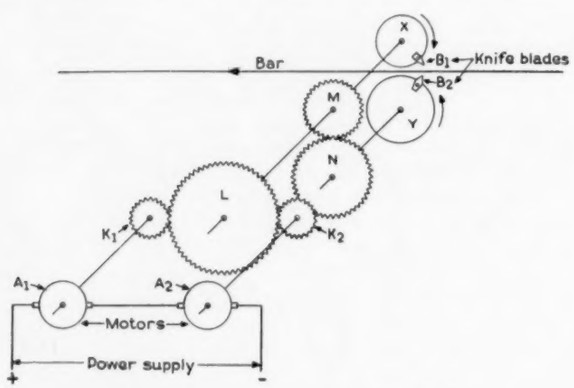

FIG. 3—Schematic Diagram of the Mesta Flying Shear.

When both knives come against each other, a cut is made; the lower or the upper knife alone may deflect the bar either upward or downward, but does not cut it. Now, if the pitch diameters of the two drums are in ratio of 4:3 to each other, and their speed ratio is an exact reciprocal, then a cut will take place every 4 turns of the drum X and every 3 turns of the drum Y. (A 3:2 ratio, instead of 4:3, is used on the skelp shear).

Both shear drums are geared together through the gears M-N, having the desired ratio. The shaft of the upper drum is driven through a larger gear L and the two pinions K_1 and K_2—by two D.C. motors A_1 and A_2; the gear ratio between K and L is in this case 6:1. A two-motor drive was preferred for two reasons: (a) a more convenient gear layout, (b) the use of standardized mill type motors, with a low armature WR^2.

With these gear ratios, the sheet bar shear motors make 24 revolutions from cut to cut; the skelp shear motors make 18 revolutions from cut to cut.

It is obvious, that the faster runs the shear for any given metal speed,—the shorter will be the cuts, —and vice versa. In other words, the length of cut depends on the speed ratio of the mill and shear.

When the two knives come together, their linear speed should not be lower than the linear speed of the stock; otherwise the stock is apt to buckle up. The knives speed may be, however, somewhat higher than the metal speed. For cutting thick bars an appreciable overspeed of the knives might be again objectionable because the blades will be then pulling and tearing the bar apart; for thin gauges the actual cutting time is so short, that considerably more latitude may be had in relatively speeding the shear up and in shortening thereby the length of cut.

The sheet bar shear in question has been actually shearing bars for the last several years, the length of cut varying from a maximum of 31 ft. down to a minimum of 25' 9".

Shear Motors

The two driving motors of each shear are of the D.C. mill type, listed as 150 HP—450 RPM—230 V. (Frame MDS-418). They were connected in series with each other across the 600 V. generator (also supplying power to main motor D), so that the continuous rating of each motor has been changed to 190 HP—600 RPM—300 Volts; speed range up to 900 RPM (or higher) is obtainable by motor field control; speeds below 600 RPM are obtainable by generator voltage.

When the rolling is completed on any of the stands 12-13-14, the motor D is not used, and the generator voltage may be adjusted to suit the shear. When the stand #15 and motor D are used, then the adjustment of the generator voltage affects simultaneously both the motor D and the shear. The shear motors have a wider field control range (1.5:1 or more) than the motor D (only 1.15:1) to take care of various lengths of cut, etc.

Shear Approach Table and Pinch Rolls

A pair of pinch rolls is set in front of the shear; their purpose is to carry the tail end of the bar after it leaves the finishing mill stand; this is a very important function, indeed, and sufficient attention must be given to these pinch rolls (as we will presently see) in order to get a satisfactory shearing.

The bottom pinch roll and the shear approach table are jointly driven by a 40 HP—500/1100 RPM—600 V. D.C. motor also fed from the same generator as the shear motors and the drive D. The top pinch roll is friction driven by the metal itself and therefore its speed is determined by the bar speed; it acts as a "measuring roller". A small A.C. pilot generator is suitably connected to the top pinch roll and is used—as will be presently shown—for synchronizing the shear with the metal. To keep the top pinch roll turning, even when no metal passes through the rolls, a small (3 HP) D.C. motor is also geared to the top roll. This motor is connected, through a block of resistance, across the 600 V. generator; when the motor is running light, the IR drop across the resistor is low and the motor runs at practically its full speed; if, however, the speed had not been set just right, and the metal speeds up or slows down the top roll, the resistor

permits the motor to readily change its speed without danger of overloading.

Speed Regulator

It was already pointed out that, in order to cut the bar into uniform lengths with the desired and necessary accuracy, it is essential to maintain in each

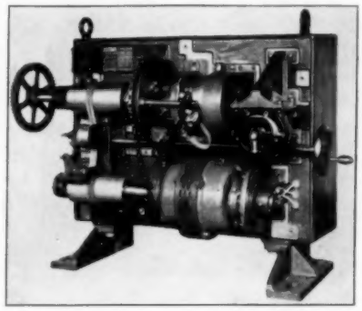

FIG. 4—Close-up View of the Regulator used for synchronizing the shear with the speed of the metal.

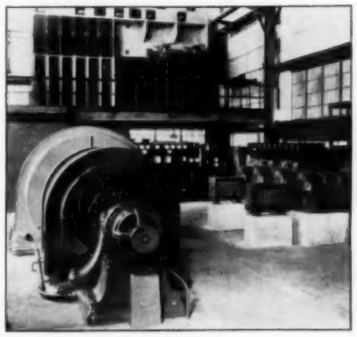

FIG. 5—General View of the Two Double-Motor Shear Drives with the Regulators; and of the Main Motor Generator Set.

case a constant ratio between the shear speed and the delivery speed of the metal. The speed of the mill may change depending on the load; this is particularly true of a group drive C, where the delivery speed at the stand #14 will go up in two steps as the tail end of the bar leaves in succession the stands #12 and #13. Furthermore, the operator is apt to readjust, from time to time, the speed of the finishing stand, in order to control the loop between the stands #14 and #15. Unless the shear speed is changed simultaneously and in a proper proportion, the accuracy of the cuts will suffer. Thus some means must be provided to automatically maintain the selected speed ratio between the delivery speed and the shear speed. In the case of this mill, the finished bar may be delivered from any one of the four stands, 12 to 15 inclusive, and therefore the delivery speed may depend on the speed of any of these stands. The change of roll diameters is also affecting the speed of the metal, for any given value of roll RPM. Under the circumstances, it was thought advisable to determine the metal speed by directly measuring it, and to synchronize the shear with this measured value. This seemed the most logical procedure and it was therefore followed.

Each of the two shear drives is provided with a so-called dynamometer type speed regulator. Fig. 2 shows diagrammatically its arrangement; this sketch is obviously not to scale. Fig. 4 illustrates the close-up view of this regulator; Fig. 5 shows the two pairs of shear motors with the regulators and the main motor generator set.

One of the two motors driving the shear is coupled to the cone pulley C-1 of the regulator; the latter transmits the motion through a belt to the second cone pulley C-2; the latter is driving the rotor R of a small synchronous motor S. The stator of the latter is connected electrically to the pilot generator PG, driven by the top pinch roll. If the speed ratio of metal to shear is correct, the speed of rotation of the rotor R is exactly the same as the speed of the rotating field created by the stator ST and therefore the stator remains stationary, even though it is mounted on bearings and is free to rotate.

If, however, the metal and, therefore, the pilot generator PG slow down so that as little as ½° of displacement takes place between the stator and rotor, the small synchronous machine exerts its full torque to move the stator. The latter then moves, through the endless chain Ch, the brush F on the commutator type rheostat Rh. This rheostat is connected in the field circuit of the shear motors and the described movement of the brush F will cause the shear motors to slow down until the balance of speeds is again re-established. If, at any time, the length of cut is to be changed for a given delivery speed, it can be readily done by shifting the belt on the cone pulleys; this belt-shifting is done remotely by means of a small pilot motor, Q. Then the condition of balance will be again maintained with a different ratio of the metal and shear speeds.

The described regulator is based on the principle of matching frequencies. Therefore this regulator is bound to react to the minutest difference between the speed of shear and the speed of the pilot generator connected to the top pinch roll. The regulator cannot fail to respond in such a case any more than any synchronous motor cannot ordinarily run at any other speed but at synchronism.

Thus this regulator is bound to be as sensitive as conceivable to the slightest variations of the speed ratio. But it is not enough for a regulator to find out quickly, that the speed ratio has been changed and that it should be corrected; it is also important to make this correction quickly. Only the combination of these two qualities—SENSITIVITY and SPEED—makes any regulator "ACCURATE".

Starting Control

It has been already pointed out that if a rotary shear is left running continuously, the first cut will be made at any distance from the front end of bar, i.e. the per cent crop will be excessive. Therefore it is essential to hold the shear at standstill, with the knives in a definite angular position and then to accelerate the shear to its proper running speed when the approaching bar reaches a definite point on the shear approach table.

Nowadays a photoelectric relay could be selected as an ideal device for this purpose. In 1926 track type limit switches were applied.

There were two flags, E and F, used, see Fig. 2. Means were provided to move them alongside the approach table. As soon as the bar strikes the flag E a signal is given to the shear control to start and accelerate the shear, A or B, depending on which one has been selected.

It is obviously important to have the shear up to

speed by the time the first cut is made. Considering the mechanical layout there is only 30 ft. of bar travel, from the instant the flag E is touched, until the first cut might be made. If the maximum delivery speed is 1200 FPM (or 20 ft. per sec.), it will take the bar only 1.5 sec. to cover this distance. When the delivery speed is at its highest, then the shear speed is apt to be also at its highest, for a given length of cut. In other words the shear should be accelerated to its maximum speed when there is a minimum time available for it. This, quite obviously, requires motors capable of developing high torques and possessing small inertia. The mill type motors answer these requirements quite well.

The starting torque requirements quite often determine the capacity of the shear motors. This is the case in the described installation. In order to accelerate the shear at a high rate it is usually advisable to cover the greater portion of the speed range by armature control,—leaving a smaller balance of the range for motor field weakening; in this manner a greater average value of torque is available during the accelerating period. Of course, this means a larger generator for supplying power to the shears, (if a separate generator is used) and an economical compromise is usually reached.

After the first cut is made, the shear continues running at its steady ("synchronized") speed, cutting the bar into uniform lengths. Now, the tail end of the bar leaves the mill; another cut or two should be allowed to be made and then the shear should be stopped. The flag switch F serves this purpose. Its location along the approach table can be also adjusted.

As soon as the bar lets this switch go, it gives proper "instructions" to the shear control, and makes effective the geared type limit switch connected to the shear. At a definite angular position of the latter switch, dynamic braking is applied to the shear motors; the latter slow down and approach at a definite reduced speed the second position of the limit switch, whereby power is completely cut off and a powerful solenoid brake is applied to positively stop the shear in its original angular position, ready for the next start.

In order to get sufficient accuracy in the length of the first crop, it is important (1) to stop the shear at the same position every time, and (2) to take the same time in accelerating from standstill to the required running speed.

Both these conditions are met satisfactorily in practice, and no difficulties are encountered in obtaining a consistent length of crop.

In the described installation, as already noted, the shear motors are fed from the main 2300 KW generator, also arranged for supplying power to the drive "D". Hence the generator field control is not available for accelerating the shear, and a separate magnetic control is provided for each shear drive. On account of the very short time available for accelerating, the usual timing relays are dispensed with, and a simple sequence interlocking is employed. After the last accelerating contactor closes, the regulator is automatically put in service and assumes control of the shear speed.

The geared limit switch is arranged to make one revolution from cut to cut, i.e. for 24 or 18 revolutions of the motors, driving the bar shear and the skelp shear, respectively. When running at the maximum expected speed, it is not feasible to accelerate the shear and to brake it to standstill, all within a travel corresponding to only one cut. For this reason a simple gear shift between the shear and the limit switch is provided; in this manner the gear ratio may be doubled, and the limit switch will then make one turn for every two cuts.

The shearing may proceed only when the shear is running at a steady speed. If the shear should be started and stopped for each bar, then a time interval must be allowed between rolling of consecutive bars, this interval being not less than the time required to accelerate and then to stop the shear. Depending on the operating speed, this time interval should be 5-6 seconds or less.

Operating Results

The shear equipment just described was put in service in 1927 and has operated, on the whole, quite satisfactorily.

The cropping of the front ends did not present any difficulties. The operators have found that instead of using the flag switches and of adjusting the length of crop by moving the flag switches alongside the table,—it was easier to start the shear by "hand", from a master switch in the pulpit; the operator moves this master switch when he sees the approaching bar reach a certain point on the table. Likewise, he would shut the shear down (by moving the master switch thereby making the geared limit switch effective) when the trailing end of the bar would pass a certain point on the table. For quickly changing orders, rolled at different speeds, etc., it certainly is easier to initiate the shear starting by hand, as described, rather than to move the flag switch; furthermore no shear operator is located on the mill floor, as was first contemplated, and only one man in pulpit controls the main drives and the shear. The cropping is done with ample accuracy,—certainly as accurately as with a steam shear.

Actual measurements of cuts, made at the bar piler, have shown that WITH PROPER ADJUSTMENTS, the cuts were within 1" from each other; this is an accuracy of almost ¼ of 1% on a 30 ft. length. However, the first cut would ordinarily be 2-3" too short, and the last cut or two would come out 2-3" too long. While the actual waste of material on this account was negligible, it was at least annoying to see the bar pile not look uniform.

A closer study has shown that the true reason for this inaccuracy was the attempt of the operator to set the pinch roll speed higher than the true metal speed. In this manner it was expected to avoid any buckling of material between the mill and the pinch rolls. This attempt was, maybe justifiable, taken by itself, but its effect on shearing was anything but pleasant.

Let us assume that the shear has been just started, in view of the approaching bar. The pinch rolls, and therefore the pilot generator are running a trifle faster than they will run after the metal enters the pinch rolls. The shear follows the pilot generator; hence it is also running a little faster than it should. Now the bar reaches the pinch rolls and pulls their speed down to the proper value. The ever-watchful regulator begins at once to slow down the shear by

a suitable amount; but the shear motors cannot respond instantly to the regulator action. The magnetic field cannot be changed instantly, and the inertia of the rotating parts also resists the sudden change of speed. Thus, while the first full-length cut passes through the shear, the average speed of the latter is slightly too high; hence the first cut is apt to be under the proper length.

After this, the conditions become stable, and the cuts come out right. Then, as the tail end of the bar leaves the mill, the pinch rolls do not feel any more the "restraining hand of the mill," and speed-up again, accelerating the bar with them. The regulator also tries to speed the shear up, but, again, it cannot do so instantly. Therefore the metal passes through the shear at a relatively higher rate than needed, and the last cut or two are apt to come out somewhat too long.

To fully prove this explanation, the pinch rolls were purposely slowed down slightly below the bar speed. The test results had checked the expectations, the first cut was now too long, and the last cut or two were too short. Finally, the speed of the pinch rolls was set with a particular care, to match exactly the delivery speed; the results were most gratifying; all cuts, including the first and the last ones, came within the 1" tolerance.

Thus, while it seems, at first, that a pinch roll, driven by the metal itself, is the best point of reference for synchronizing the shear, in practice this method possesses certain shortcomings. To make it successful, the operators must always be "on their toes" in setting the pinch roll speed. With some little training and proper attention, on the part of the operators, fairly good results, from practical standpoint, may and are being obtained.

The operators' task might be simplified, if a speed regulator were provided between the pinch rolls and the mill. In this manner their speed ratio would be maintained, regardless of manipulation of the mill speed. But even then the operator is apt to establish a wrong speed ratio, i.e. to set this regulator to hold the pinch roll speed too high; the first and the last cuts are apt to be off again. Thus, this phase of the problem is really out of the hands of electrical engineers.

Length Measuring Device

An electrically driven shear cuts the metal into uniform lengths. How is such shear set up, to obtain the desired length? How does the operator know what is the length of cut he is getting?

The length of cut depends on the ratio of speeds of shear and metal. Knowing the RPM of the finishing stand and the diameter of the finishing rolls, the delivery speed of the bar may be **calculated**, or taken from a previously calculated table. The same table also tells what should be the shear speed for a given delivery speed and the desired length of cut. In this manner the shear speed may be pre-set beforehand.

No tachometer can give a better accuracy then say 1%, considering the human element which enters in making the reading. At least two tachometer readings are involved in the described shear set-up. Thus, a potential error of 2% is conceivable. This is about 7 inches on the 30 ft. length. True enough, such an error is not certain, it is only conceivable. Just the same, the operator, in order to play safe, is apt to set the shear to cut slightly longer lengths, rather than to get the cuts too short. Excessive length of sheet bars or skelp means higher per cent scrap in the finishing departments.

It is not so easy to directly measure the cuts, right after they are made. The bars, thrown on the piler, do not lay with their front ends even; a casual observation will not tell whether the length of cut is right or not. The bars are hot; an actual measurement by a tape or a rule is not practicable, until the bars have cooled off, i.e. until the time when the shear operator may be already busy with the next order, calling for a different length of cut.

These facts led to a design of a very simple, but effective, "length-of-cut meter". A selsyn transmitter is connected to the top pinch roll; a selsyn receiver is installed in the operator's pulpit. This receiver is connected through a small magnetic clutch to a recording dial. Ordinarily, the clutch is disengaged, and the dial is set at zero (by a spring or otherwise). An extra segment on the shear limit switch is utilized. It is arranged to close a circuit when a cut is made, to maintain it closed until the next cut, hold it open until the third cut, and so on. This contact is put in the circuit of the above magnetic clutch.

Whenever the operator wants to check the length of cut, he presses a button; this makes effective the limit switch segment, just described. The clutch is engaged when the next cut is made; the dial starts turning at a speed proportional to the top pinch roll, i.e. to the metal speed; at the instant of the next cut the clutch is disengaged; the meter therefore indicates the length of bar which had passed through the pinch rolls from cut to cut, i.e. the **length of cut.**

This instrument permitted to check the shear performance during the shearing. It enabled the operators to hold much more accurately the length of cuts. In this manner, it has paid for itself many times over.

It might be noted, in passing, that an identical instrument, called a "pack measuring device", was very successfully applied to sheet mills, to give a quick and visible indication of the proper elongation of the pack.

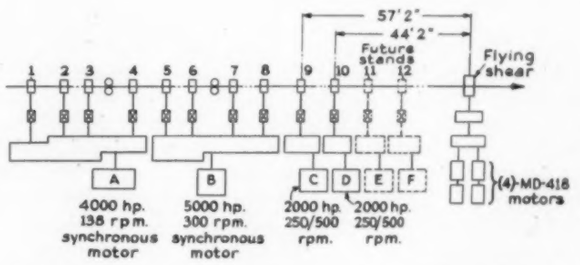

FIG. 6—General Layout of the 21" Bar and Billet Mill, Great Lakes Steel Corp., Detroit, Mich.

ANOTHER BAR MILL SHEAR

Mill and Shear Layout

The experience gained on the shear equipment just described was taken full advantage of in laying

out the electric drive for one of the subsequent shears of similar nature.

This shear was installed at a 21" continuous Bar and Billet Mill, built in 1929 for a steel plant in the Great Lakes Steel Corporation, Detroit, Mich. The general mill layout is shown on Fig. 6. The rolling is always completed on either stand 9 or 10, each driven by a D.C. motor, 2000 HP, 250/500 RPM, 600 V. For certain sections these motors may operate at reduced speed and voltage. The delivery speed may vary, therefore, within very wide limits, varying from less than 200 FPM to over 900 FPM. As two additional finishing stands may be added in the future, the shear equipment was laid out to deal with delivery speeds up to 1500 FPM.

The mechanical design of the shear itself is substantially the same as shown on Fig. 3; the two drums have a diameter ratio of 4:3, and the gearing is such that the driving motors make 24 revolutions from cut to cut.

When the knives travel at exactly the same speed as the metal, the length of cut is 31 ft. 5 in. By speeding the shear up above the metal speed the length of cut is reduced a certain amount; the thinner is the stock, the larger may be the amount of this relative over-speeding, and therefore the greater the possible adjustment in the length of cut.

All things considered, the operating speed range of the shear motors was selected as 178—1250 RPM. To obtain such a wide range it was necessary to use a combination of generator and motor field control.

For shearing large billets a total torque of about 20,000 lb. ft. was required at the motor shaft. It was also desired to employ mill type motors duplicates of those used on all mill auxiliary drives of this steel plant. Thus 4 motors were selected, each having a listed rating of 150 HP—450 RPM—230 V.

The motors were arranged in pairs; two motors in each pair were permanently connected in series; the two pairs can be connected either in series or in multiple. A separate 350 KW, 600 V. generator was provided; this gives 300 volts per motor, and brings the rating of each motor to 190 HP, 600 RPM, with a motor field control up to 1250 RPM.

It is interesting to note that the generator rating (350 KW) is about one-half of the total shear motor rating (760 HP). The point is, that the motors are called upon to deliver their maximum torque (say 5000 lb. ft. per unit) at the low operating speed only, when all four motors are connected in series; at high operating speeds, with motors connected in two parallel circuits, the torque requirements are much lower. Thus the generator was designed only for the maximum current of one motor circuit, without jeopardizing in any way the drive capacity. The first cost of the equipment was correspondingly reduced.

Speed Regulator

It was further decided to synchronize the shear with the finishing stands, #9 or #10, as the case might be, the speed of which determines the delivery speed, rather than to measure this speed by a measuring roll (top pinch roll). Quite obviously, the metal enters the finishing stand a second or more earlier than it enters the pinch rolls; hence more time is given to the regulator to adjust the shear speed. With a reasonably fast regulator, the first cut may be, and is being, made of the same length as the subsequent cuts.

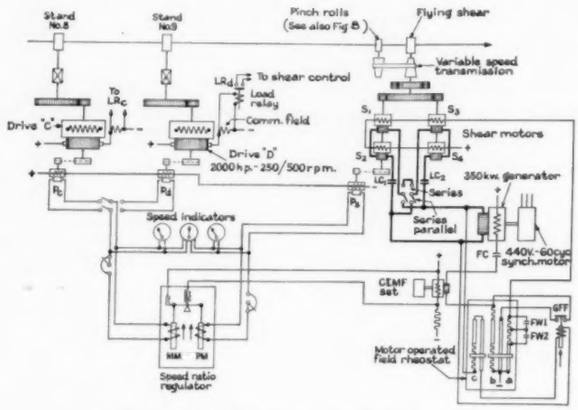

FIG. 7—Simplified Shear Control Diagram.

The selected speed ratio regulator is of a balance-relay, vibrating type, see Fig. 7. Each of the mill drives, C and D, as well as the shear were equipped with a small D.C. pilot generator. One of the two main coils of the regulator (PM) is connected to the pilot generator of the shear; the other main coil (MM) is connected selectively to the pilot generator of drive C or D, depending on which stand, 9 or 10, is used as the finishing stand. The regulator remains in balance if the currents in both coils are equal; if the shear slows down, for any reason, the balance is upset, and the regulator speeds the shear up until the balance is re-established again. By means of the adjusting rheostats in the coil circuits the condition of balance may be adjusted for various ratios of speeds, i.e. for a different length of cuts.

Means are provided to increase the sensitivity of the regulator and to make it respond to as little as ¼% deviation of speed ratio. This is not as sensitive as the dynamometer regulator previously described. A balance regulator may not feel a smaller variation in relative voltages while a regulator based on matching of frequencies will not "quiet down" unless the frequencies are exactly matched. On the other hand, the vibrating regulator is a faster-acting device and, by "forcing" the generator field up or down, is capable of quickly changing the shear speed. In other words, what was lost in sensitivity was to be more than made up in quicker action; as the true accuracy is the resultant of these two features, it was expected to maintain a better consistency in the length of cuts. Experience has proven that with either type of regulator the ultimate accuracy of cutting is about the same, as long as the equipment is maintained in good condition.

Control

With a special generator assigned for furnishing power to the shear, it was possible to make the regulator act on the generator field rather than on the shear motor fields; this is advantageous as the former is somewhat faster.

The shear motors are started by applying the

generator field in one step (Field Contactor FC). The field rheostat and permanent resistor in the field circuit are temporarily short circuited by a contactor, (GFF), and the voltage quickly builds up; when it reaches the proper value, as determined by the field rheostat setting, the contactor GFF drops out and the field forcing ceases. Then the motor field weakening contactors FW-1 and FW-2 drop out in sequence. In this manner a very rapid acceleration is obtained, and there is no difficulty in bringing the shear to its maximum speed in the short time available.

When the shear is to be stopped, the motor field is strengthened and the generator field is quickly weakened; the regenerative braking quickly reduces the shear speed to the creeping value. Then, the generator excitation is completely removed and the solenoid brake finally stops the shear. A geared limit switch, connected through a worm speed reducer to the shear motors determines the instant of the "slow-down" and of the "final stop", and insures that the shear consistently stops in the same position of knives, bar after bar.

Means are provided to initiate the starting and stopping of the shear automatically. A load relay LR_d (of a potential type) is connected across the series field the 2000 HP finishing mill motor D. This relay picks up at the instant when the bar enters the finishing mill. A timing relay is employed to determine the delay between this instant and the initiating signal to start the shear; this relay is of a magnetic type and the timing is readily adjusted within needed limits by means of a small rheostat in the pulpit. In this manner the operator can easily adjust the length of the first crop. Once adjusted, the relay maintains this length, as long as the delivery speed is not altered.

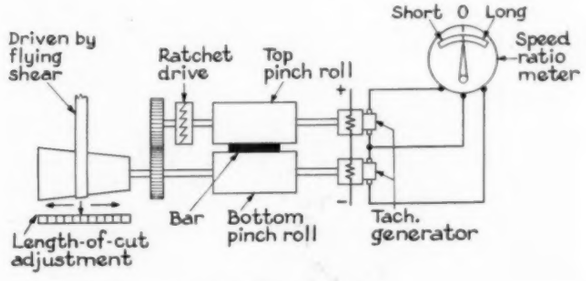

FIG. 8—Pinch Roll Drive.

When the bar leaves the finishing stand, the load relay drops out; this initiates another timing relay, and after an adjustable time interval, the latter "instructs" the shear to stop; in other words it makes the geared limit switch effective, and the latter functions as described.

The performance of these devices has proven to be so reliable and consistent, that the problem of cropping, with shears of this type, may really be considered as solved.

Last Cuts and Pinch Rolls

There remains yet the problem of making the last few cuts (after the bars leaves the mill) as accurate as the other cuts. The arrangement made in the described case is very interesting, and serves two purposes:

1) to match the pinch roll speed with the delivery speed,
2) to indicate the length of cut while the shearing proceeds.

The shear approach table and the bottom pinch roll are mechanically driven from shear itself, through a variable speed transmission, see Fig. 7. While a Waterbury Hydraulic Gear is actually employed, we may conceive for simplicity sake that a pair of cone pulleys and a belt shifter are used; thus, IF THE TABLE SPEED AND THE MILL DELIVERY SPEED ARE MATCHED, the position of the belt shifter will indicate the length of cut.

The top pinch roll is also mechanically driven from the shear, (see Fig. 8) but through a ratchet arrangement and at a speed somewhat lower than the bottom roll; i. e. it runs at a lower speed than the bar when there is no metal in the pinch rolls. As soon as the metal enters the pinch rolls, however, the billet will drive the top roll ahead, at the exact delivery speed, overhauling the ratchet.

Tachometer generators are connected to each of the pinch rolls and are connected to a differential voltmeter. When the peripheral speeds of both rolls are equal, the pointer of the voltmeter is on its zero center, indicating that the table and pinch roll speed matches exactly the mill speed.

With this arrangement the operator sets, first of all, the belt shifter (or equivalent) to correspond to the length-of-cut desired; a suitable calibrated dial is provided for this purpose. The shear speed is then adjusted to about the right value, the operator using reference tables as a guide; when the first bar goes through the pinch rolls, the shear and table speed are finally adjusted, by bringing the differential voltmeter pointer to zero. From that instant on, the regulator assumes full control and maintains the desired ratio. The operator, by watching the voltmeter pointer, can readily see whether this ratio (i.e. the length of the cut) is off or not.

If the pinch roll speed exactly matches the mill speed, then the length of the last cuts will not differ from the average. The arrangement just described gives the operator a very easy means to get these results. But if he still attempts to run the shear approach table and the pinch roll at an overspeed, then he is sure to get the last cuts too long, and no regulator will help him out.

The number of these "last cuts", depends entirely on the distance between the finishing stand and the shear. The shorter is this distance, the more accurate the shearing is apt to be. If there are no other objections, the shear should be set as close to the finishing stand as possible. The time required to accelerate the shear from standstill to full speed should not influence this decision; after all, the signal to start the shear can just as well be timed when the bar passes through some of the intermediate stands. As the delivery speeds of the several adjacent stands are definitely fixed, for any given rolling schedule, the time required for the bar to travel from, say, the stand #7 to the shear is just as definite as time required to travel from stand #10 to the shear. A load relay actuated by the current of the motor driving the stand #7, plus a timing relay, again may be used for adjusting the

length of the first crop. If the several stands are driven by a common motor, the application of the load relay may not be always successful; the load imposed by, say, the stand #7, in case of a light draft, may constitute too small a percentage of the motor rating. In this case a photo-electric relay located at that stand, plus a timing device may well answer the purpose.

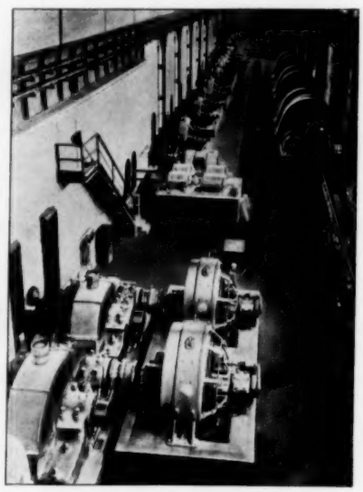

FIG. 9—General View of Motor Room of the 21" Bar Mill, Great Lakes Steel Corp., Detroit, Mich. The two 2000 HP. D.C. Motors (drives C and D) are in the foreground; the four shear motors, mounted on a high foundation, are in center; the 10 D. C. motors in background are driving the 34" hot strip mill.

The performance of this shear has proven rather conclusively that it is advantageous to synchronize the shear with the mill, rather than to do so with the pinch roll driven by the metal. The first regular cut comes out of the same length as the average, thus eliminating one of the annoying features.

The accuracy of the cuts (except the last ones) is well within ½ inches on a 30 ft. length, which really is quite satisfactory for all practical purposes.

IS THE SPEED REGULATOR REQUIRED?

Since there are a number of these shears now in service, it is quite natural to ask: do the speed regulators do any good? Could the shear operate just as successfully without a regulator?

The writer has asked himself this very question a number of times; only experience could have given a fair answer. Thus on some occasions the regulator was actually cut out of service, without the operators knowing it (the belated apologies are hereby offered!), and the results observed.

With a steadily running mill, one bar following another of identical size etc., it was practically impossible to detect any difference between regulating and non-regulating operation. If the relative speeds of the mill and shear change, and a good and reliable differential instrument indicates this change at once, then the operator—if he is on his toes—may correct this change by adjusting a rheostat before many off-length cuts are made; i.e. he will do what the regulator is supposed to do. Thus the regulator should be likened to a good, attentive and quick-acting operator correcting for relatively slow changes of conditions. As such ideal operators are few and far between, it still seems that a good regulator is essential, as long as no other means are provided to tie-in the mill and the shear.

The regulators of any described type, act on the field of a D. C. motor or of a generator furnishing power to it. The regulator may be as fast as the art knows how to build it, but as long as it has to work through a magnetic field of any kind, a certain lag between the "cause" and the "result" is bound to occur. Furthermore, no regulator anticipates the change of speed; it feels this change only after it has taken place, fully or partly, and only then it starts its corrective action. All told, it is rather hopeless to expect that any regulator, now known to the art, is capable of correcting any speed change within a period between two consecutive cuts; when cuts are made at a rate of 30 or more per minute, 2 or 3 cuts are bound to come off length before the final correction is made.

As long as we have to deal with D. C. machines for shear drives, it should be considered as a forward step to furnish power to the shear motor from a D. C. generator driven by the mill itself. This, in itself, provides a speed-tie between the two elements: the shear motor certainly will respond more quickly to any change of the applied voltage, than to the re-adjustment of its field strength. This D. C. system will not constitute, of course, a true synchronous tie; a good regulator should supplement the equipment, to give the needed fine speed ratio control. But the task of the regulator will be an easier one, and the whole equipment should give more satisfactory results, than if the regulator alone constituted the sole tie between the mill and the shear.

The obvious objection to this arrangement is its cost when the rolling may be completed on more than one stand, each stand driven by a separate motor. This means that several D. C. generators would be needed, one per each finishing stand. Furthermore, the speed of the several mill motors is usually lower than the most economical speed of the shear generators; step-up gears or belt drives are conceivable, but they add to the cost and it is questionable whether the operators would like them. Thus this arrangement should be considered primarily for cases when rolling is always completed on the same stand, or when the several finishing stands have a common driving motor.

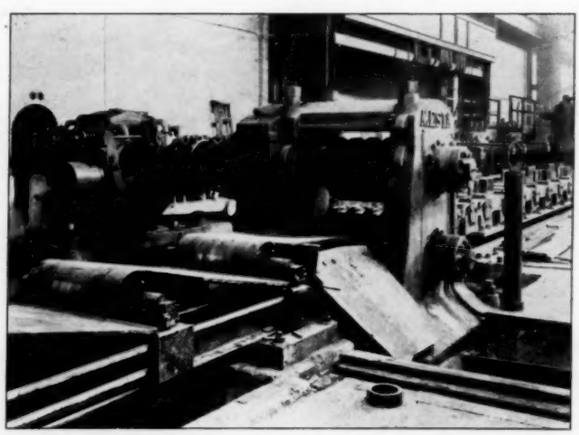

FIG. 10—Mesta Flying Shear at the 21-inch Bar and Billet Mill, Great Lakes Steel Corp., Detroit, Mich.

SPECIAL CROPPING CONTROL

Principles

We have assumed thus far, that in order to crop the front ends of the bars, the shear should be stopped after each pass and then started again, as this has been described. Broadly speaking this is not the only solution of the problem, nor is it always the most economical one.

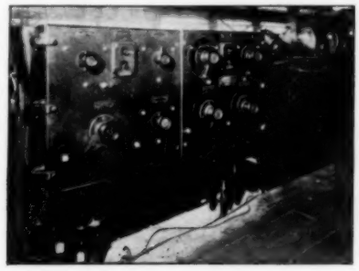

FIG. 11—Pulpit Control Cabinet for the Flying Shear. (See also Figs. 7-10).

With a high speed mill, rolling relatively thin gauges (but not thin enough to disregard the loss due to cropping), the capacity of the shear motor is determined not so much by the torque required for cutting the metal, as by the torque required to accelerate and retard the shear very quickly within the limited time available between the consecutive bars. If the amount of this accelerating and retarding work could be materially reduced, the capacity and cost of the shear drive could be also brought down.

After all, what is our problem? If the blades of the rotating shear were always in the same angular position when the approaching bar, delivered at a definite speed, reaches a definite point on the table, —then the first crop would always come out right. But actually the blades may be either behind or ahead of this ideal position. If we could, therefore, detect this angular difference, then temporarily accelerate or retard the shear until this difference is wiped out, and then let the shear continue running at its proper speed,—then the cropping problem would be solved. The power required to partially accelerate or retard the shear is certainly less than that needed for starting from standstill. Thus there is a possibility of reducing the first cost of the machines.

Installation

An equipment embodying these principles was laid out in 1930, and was built and actually put in service. While the mill and shear layout was somewhat unusual, the elements of the cropping control stand out quite clearly.

Fig. 12 shows a part of the mill layout, required to understand the shear operation, and also the elementary electrical connections.

This is a combination strip and merchant mill, consisting of a continuous train of stands 1 to 9 inclusive, and of a finishing looping train. The shearing is done on strips only; the strips are rolled on the continuous train, and are always finished on the stand #9. Due to the special mill layout, the distance between the stands 8 and 9 is as large as 150 ft.

The stand #9 is driven by a 1000 HP—200/600 RPM—600 V. motor, geared to the rolls. The rotary, shear is also driven from the same motor, a variable hydraulic speed transmission being used between the gear unit and the shear; the speed ratio between the mill and the shear is therefore, varied mechanically, to suit the length of cut desired.

As far as the accuracy of cuts is concerned, this arrangement is simple, economical and effective. But it does not take care of the cropping; the first cut is apt to come anywhere. To correct this shortcoming the following control was furnished.

Referring again to the Fig. 12, assume that for a given set of conditions (i. e. for a given mill speed and length of cut) the shear knives **should be** in the position "x" when the strip first enters the stand

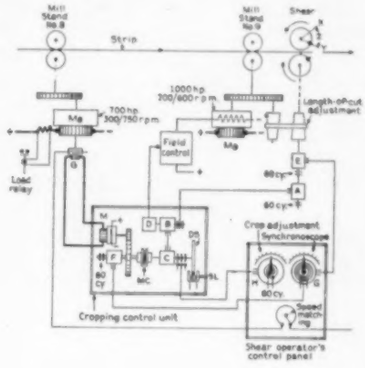

FIG. 12—Diagram of the Special Flying Shear Control for cropping the front ends.

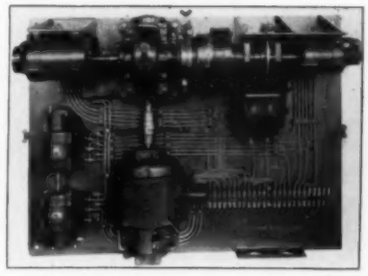

FIG. 13—Plan View of the Control Unit for the Flying Shear, Fig. 12.

#8. However, at that instant the knives might be in the position "Y". It is, therefore, necessary for the control to temporarily speed up slightly the stand 9 and the shear, to wipe out the angle "z" by the time the motor #9 is back to its original speed, and to do all this before the strip reaches the stand #9. If the preceding strip is still going through the shear during this "readjustment" process, the accuracy of the cuts will not be affected, as the speed ratio between the stand 9 and the shear remain rigidly fixed.

The simple, but ingenious devices, known in the trade as "Selsyns" were freely used in this control. One Selsyn, A, is connected to the shear drum; therefore, its angular position corresponds to the position of the knives; we may say therefore that the Selsyn A "knows" where the knives are.

Another Selsyn, C, is located remotely from the mill and remains stationary at an angle indicating where the knives should be when the metal enters the stand #8. At just this instant, the Selsyn, C, should be picked-up and then rotated at exactly the correct speed. Thus we will have then two Selsyns rotating, one of which (C) indicating where the shear blades should be at any time after the strip

strikes the stand #8, while the other (A) indicating where the shear blades actually are.

Now, the output of these two Selsyns, A and C, is brought to the stator and rotor, respectively, of a differential Selsyn B; then the position of the latter will indicate the exact angle between A and C, i. e. the angle "Z". If this angle is, say, "positive", i. e. if the shear blades are behind the correct position, then the control should temporarily speed-up the 1000 HP motor #9; if the angle is "negative", then the control should temporarily slow-down this motor. To do so, another Selsyn "D" is coupled to B, and its output is used to control, through suitable devices, the excitation of the motor M9.

It remains to be seen, how the Selsyn C is rotated at the exactly correct shear speed after the bar strikes the stand #8. A small D. C. pilot generator G is connected to the 700 HP—300/750 RPM motor driving this stand; this generator furnishes power to a small D. C. motor M, driving through gears and a magnetic clutch the Selsyn C. For any given strip speed, and needed length of cut, the speed of the motor M may be adjusted by means of the rheostats, so as to match exactly the speed of the pilot motor M with the shear speed. A simple synchronoscope, consisting of Selsyns E, F and G, provides an excellent and simple means for this speed matching. When the strip enters the stand 8, the load relay of the 700 HP motor picks up, the magnetic clutch is engaged, and the Selsyn C starts rotating at the shear speed, and the speeding-up or slowing-down of the motor M9 begins.

After the first crop has been made, the clutch MC is de-energized and the Selsyn C is returned to its original position; a copper disc DS, carrying an iron slug, and a small solenoid magnet (SL), which is then energized,—serve the purpose of properly biasing the angular position of C.

Thus we have means of maintaining the proper length of cropping. Suppose the operator wants to make it somewhat shorter or longer. How will he do it? Instead of energizing the rotor of Selsyn C directly from the 60 cycle supply, we interpose another Selsyn-transformer H; the rotor of the latter is connected to the 60 cycle power, while the stator—to the rotor of C. Selsyn H can be rotated by hand a limited amount; this has the same effect as if stator of C were rotated the same angle in respect of the disc DS, or vice versa. The Selsyn H is provided with a handle and a dial, and the operator adjusts the length of cut by turning this dial.

Possible Applications

This arrangement, although conceived for a rather unusual mill layout, points out quite clearly how it can be adopted to a conventional flying shear. Let us assume that the stand 8 and the motor M8 are the finishing stand and its drive, respectively. The motor M9, much smaller in capacity, is driving the shear; the mill stand #9 does not exist, and is replaced by a set of pinch rolls; the motor M9 would be undoubtedly connected to the shear in a fixed gear ratio, while the variable speed transmission of some kind would be used between this drive and the pinch rolls (as less power is then transmitted through it).

The speed ratio between the pinch rolls and the shear would then be set for the necessary length of cut. The motor M9 would then be speeded up or down until the speeds of the mill and of the pinch rolls are matched,—just as this has been done on Figs. 7 and 8. Then the motor M9 would be let running continuously.

A Selsyn equipment as has been shown on Fig. 12, or its equivalent would serve to secure the proper length of crop. After the first cut, the Selsyns would be left in operation, continuing to maintain the positional synchronism between the traveling bar and the shear knives. In other words, the Selsyns will act as a speed regulator, in addition to serving for cropping control.

The speed tie between the finishing mill motor M8 and the Selsyn C is obtained through two small D. C. machines G and M; by adjusting the field of either, the speed ratio between the M8 and C may be readily changed. While, admittedly, this is not a "synchronous tie", it gave a very good accuracy, in the equipment actually built and installed; the load which the machines G and M actually carry (they transmit only "control power") may be readily made so much lower than their normal rating, that such variable factors as IR drop etc. are practically eliminated.

If, however, the control is used not only to regulate the cropping, but also to keep the bar and shear in synchronism, then a true synchronous tie might be found desirable; the machines G & M will be then replaced by two Selsyns; a variable speed transmission will be introduced between M8 and G, or between M and F-C.

Mechanical Cropping Control

A very simple control of the front end cropping may be readily provided, if the mill layout and the plan of operations permit it. Let us assume a continuous strip mill. The distance between the roughing and the finishing stands is so large that a slab is free on the table between these two groups of stands.

The shear is driven mechanically from the last finishing stand, through any suitable variable speed transmission such as a Waterbury gear or like. This shear is running continuously. A limit switch is geared to the shear to indicate electrically the position of the blades.

Now the slab is held by an electrically operated stop on the table between the roughing and the finishing stands. At the proper position of the shear blades, the above limit switch releases the stop and the slab is permitted to go through the finishing mill. The first cut will be made a proper distance from the front end.

When the mill speed changes, the time required to travel through the finishing stands also varies. Therefore, a new setting of the limit switch is required. Or, still better, the limit switch is not tampered with, but a timing relay is introduced between the limit switch and electrically operated stop on the mill table; this relay is remotely controlled and the length of crop is quickly adjusted to suit conditions.

SYNCHRONOUS MOTOR SHEAR DRIVES

In all described cases the flying shears were driven by D. C. motors, and the proper speed relationship was maintained through a regulator of one kind or another. This is, frankly speaking, only an approach to an ideal solution. A true synchronous tie is not possible with D. C. machines; they may be compared to a clutch, permitting a certain amount of slippage.

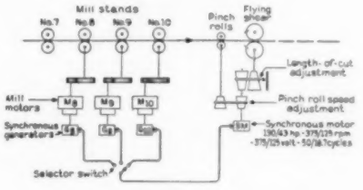

FIG. 14—General Arrangement of the Synchronous Motor Driven Flying Shear, at the 34-inch Hot Strip Mill, Great Lakes Steel Corp., Detroit, Mich.

There is nothing that runs in a synchronism better than two ends of a short and rigid shaft. It would be best and simplest, whenever possible to drive the flying shear mechanically from the mill itself. The length of cut could then be adjusted by varying by mechanical means the speed ratio between the mill and the shear. Either a gear box, a set of cone pulley or belts, or a Waterbury hydraulic gear could be employed, as long as these devices do not slip, and the speed ratio, once fixed, remain rigidly constant.

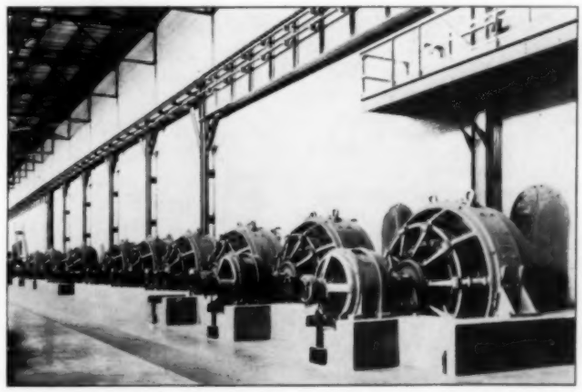

FIG. 15—D. C. Motors, driving the finishing stands of 34-inch Hot Strip Mill with coupled synchronous generators for furnishing power to the flying shear (see diagram, Fig. 14).

If the shear is required to cut the material into finished lengths, with an accurary of, say, 1/8" on, say, 10 ft. length (this is about 1/10 of 1% accuracy), then no D. C. electrical tie should be considered; the change of speed ratio should be done mechanically. But even then there is a legitimate field for electrical equipment. A large continuous hot strip mill, Fig. 14, consists of 10 stands: the stands Nos. 8, 9, and 10 are each driven by a 2000 HP—250/500 RPM D. C. motor. The maximum delivery speed on the stand 10 is close to 1500 RPM. The material delivered is cut on the fly by a rotary shear located rather close to the stand #10. The length of cut is varied in a ratio of 2:1. An accuracy of 1/8 of 1" or better is essential.

Since three stands, 8, 9 and 10, may be selectively used as finishing stands, it would be complicated to provide a selective mechanical tie between the flying shear and any of these stands. The problem is easily solved electrically.

The shear is driven by a synchronous motor SM, through a hydraulic speed transmitter, permitting the adjustment of the speed ratio between the limits of 1:1 to 2:1. The synchronous motor is rated 130 HP—375 RPM—375 Volts—50 cycle—16 pole with a maximum torque up to 4000 lb.-ft. The pinch rolls are also driven mechanically from the synchronous motor, a pair of cone pulleys with a slight taper taking care of pinch roll speed adjustment to suit the variations of roll diameters in the mill stands.

The power to the shear motor is taken from one of the three synchronous generators, connected to the motors M8, M9 and M10, depending which stand is used for finishing the strip. These generators are designed with 8, 10 and 12 poles, respectively; the gear ratios between the driving motors and the three mill stands are inversely proportional to the number of poles in the generators. In other words, regardless of which generator is used, the generated frequency and therefore the shear motor speed is always proportional to the RPM of the then finishing rolls.

The hydraulic speed changer is used for changing the length of cut as well as for compensating for various roll diameters. A suitable dial is provided, to enable the operator to set the speed changer and to let him know in advance what length of cut will be obtained.

Thus this shear equipment is electrical, as far as the tie between the mill and the shear is concerned; being a synchronous power tie it is as positive as a rigid mechanical connection. As to the length of cut, it is adjusted and maintained by purely mechanical means.

The operating results with this shear were most gratifying; the accuracy of the cuts was well within the specified tolerances. The last cuts could be held within the same close limits by the proper adjustment of the belt shifter between the shear and the pinch rolls.

Ordinarily this shear is left continuously running, with no attempts being made to crop the ends. With a thin material like strip, and with a relatively short length of cuts, the amount of scrap due to absence of cropping is not high enough to justify stopping and starting this shear for each bar. However, the electrical equipment is so arranged that it is possible to start, accelerate and then to quickly stop the shear motor in a definite angular position, with the mill running. In this manner the cropping feature may be readily introduced, if and when desired,—particularly in case of heavier sections, rolled at relatively low speeds.

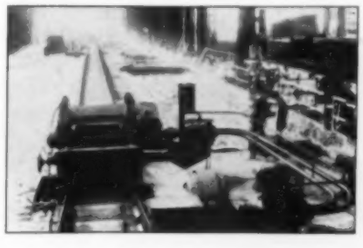

FIG. 16—Shear Approach Table and Flying Shear driven by a Synchronous Motor, Great Lakes Steel Corp., Detroit, Mich.

SHEARS WITH NON-UNIFORM ROTARY MOTION

The rotary shears which we have thus far considered are running at a steady speed, from cut to cut, once the first crop has been made. The speed of the knives cannot be lower than the metal speed while the cut is made. Therefore, with the steady shear speed, it is impossible to make a longer cut

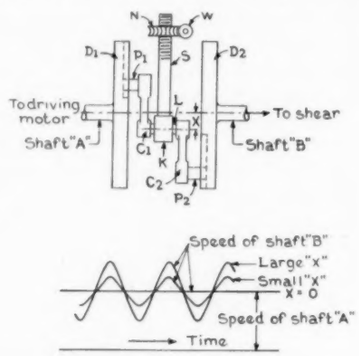

FIG. 17—Elementary Diagram of a Flying Shear with a non-uniform speed of knives. (United Engineering & Foundry Co.)

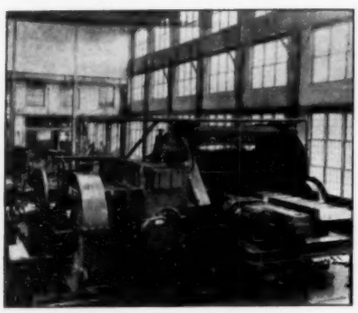

FIG. 18—Shop View of Rotary Flying Hot Strip Shear built by the United Engineering & Foundry Co. for Otis Steel Co., Cleveland, O. Maximum strip speed—300 ft. per min.; strip is free from mill during shearing. Principle of operation similar to Fig. 17.

than the length traveled by the knives, from one cut to another. Shorter cuts are possible, but not within very wide limits, and—as we have already noted—for relatively thin gauges only.

These, and other considerations, led to the design of shears, whereby the knife speed is not necessarily constant during one cycle. Suppose the metal speed is 600 FPM or 10 ft. per sec.; let the knife speed be also 10 fps at the instant of cutting; but now, right after the cut we will slow-down the knives and will then again bring them to proper speed for the next cut; thus the **average speed** of the knives is lower than that of the metal; say it is 5 fps. Therefore, it takes twice as long for the knives to travel from one cutting position to the next one. Hence, more metal will go through the shear in the meantime and the cut will become longer.

Likewise, the shear may be temporarily accelerated between consecutive cuts, reducing the elapsed time and shortening, therefore, the length of cuts; the knife and metal speeds still match at the instant of cutting.

In other words, the knife speed is made oscillatory during each cycle. These results can be obtained either electrically or mechanically.

Suppose an electrically driven shear follows the mill, as on Fig. 6, and the length of cut is varied by adjusting the motor field strength. The shear may be equipped with a special geared limit switch, which will be arranged to cut some resistance out of the field circuit and then to cut it in, all during one cutting cycle. This will reduce the average shear speed and will lengthen the cut. If, instead of cutting some resistance out, the limit switch will temporarily insert some resistance in, the average shear speed will be increased, and the length of cut will be reduced. By adjusting the amount of this resistance, the control of length of cut may be obtained, by the "cut-and-try" method.

Quite obviously, the speed regulator would attempt to counter-act the described performance by trying to hold the shear speed constant. Therefore, the shear should then be run either without any regulator, or another regulator should be provided which would merely respond to the **average** shear speed, and not to the instantaneous changes of this speed, within a cutting cycle.

Other electrical arrangements are conceivable, but it is believed that the fundamental principle is made sufficiently clear.

The same oscillatory action of the shear may be obtained by purely mechanical means.

Suppose, see Fig. 17, the shear driving motor is connected to the shaft A; the shear itself is driven from shaft B. Both shafts are in line with each other and each carries a disc D_1 or D_2 respectively. A connecting shaft L carries two cranks C and C_2; each crank is provided with a pin, P, or P_2, sliding in the radial slots of the discs D_1 and D_2. The position of the shaft L (i. e. the eccentricity x) may be varied by means of a nut-a-screw mechanism, as diagrammatically shown.

Now, if the shaft L is concentric with the shafts A and B, (x = o), the instantaneous speeds of B will be exactly equal to those of A, as if the two shafts were rigidly coupled. The greater is the eccentricity x, the larger are the variations of the instantaneous speeds of shaft A as compared with the steady speed of A. Of course the **average speeds** of both shafts are always equal because both make the same number of revolutions in a unit of time.

The Fig. 17 does not represent, of course, the actual construction of a shear but merely the kinematic principle involved. A shear built on this principle by the United Engineering and Foundry Co. is shown on Fig. 18; this shear cuts hot strip which is free from the mill and is traveling up to 300 ft. per minute.

Another manufacturer (Morgan Construction Co.) employs a different arrangement, diagrammatically shown on the Fig. 19. The shear is driven by a motor M maintaining a steady average speed, with or without a regulator synchronizing it with the mill. The pinch rolls may be also driven from the same motor, through a system of cone pulley and a belt,—as it has been done on other cases.

The motor drives the shear through a mechanism which may be likened to a differential DF. If the planetary gear, PG, of the latter is stationary, then the shear drums rotate at any instant at a speed, corresponding exactly to the motor speed. Now suppose we connect the planetary gear through a gear B, crank shaft CS and a crank C, to the same motor drive; then the speed of the gear PG will oscillate in a definite manner during one cycle and will either add or subtract a supplementary value of instantaneous speed to the shear drums. In this manner the length of cut may be varied.

This adjustment is made by changing the crank radius X or by a similar mechanical change. As this movement can be provided with a calibrating dial or scale, it is possible to know in advance the length of cut which will be obtained for any given speed of the driving motor. Of course, the problem of synchronizing the shear motor with the mill still remains; as long as the motor itself should run at a steady average speed, any conventional speed-ratio regulator may be chosen for this application.

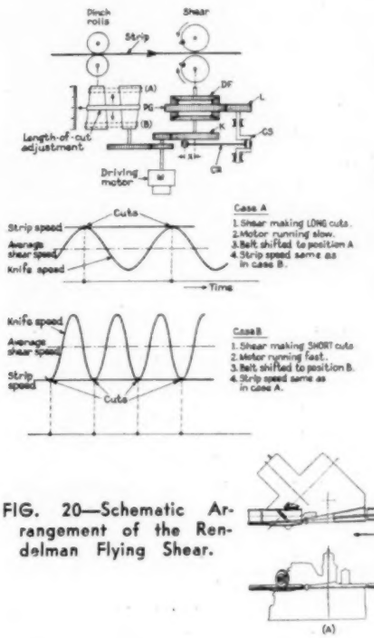

FIG. 19—Elementary Diagram of a Flying Shear with a non-uniform speed of knives. (Morgan Construction Co.)

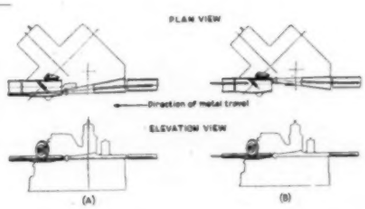

FIG. 20—Schematic Arrangement of the Rendelman Flying Shear.

FLYING SHEARS CUTTING METAL FREE FROM MILL

It happens that in some cases the metal is finish-rolled without shearing, and then the bar or the strip is delivered to a shear for cutting into definite lengths. If the shearing should be done on the metal in motion, then we have to deal again with flying shears.

Although the design of the shears themselves may be quite similar to the ones already discussed, the electrical problems are incomparably simpler. With the metal free from the mill throughout the shearing period, it is usually possible to drive the approach table, or the pinch rolls, or both, from the shear motor. A mechanical speed changer can be interposed between the shear drive and, say, the pinch rolls; it may be a gear box, or cone pulleys, or a hydraulic transmission; the amount of power transmitted is relatively small, and any one of these speed changers can be usually provided, so as to vary the length of cut.

As long as the shear motor itself controls the delivery speed of the metal, the shear becomes a "master in its own house". It is not required to follow the speed of any other drive; no speed regulators are needed. The electrical equipment may be reduced to the simplest elements; an adjustable speed D. C. motor with a field rheostat is about all that is needed.

CROP AND PARTING SHEARS

When a finished product is delivered from the mill directly to the cooling bed, and the bed's length is limited, it is essential to cut the bar into several lengths. This cutting is done on the fly, at the mill delivery speed, and hence a flying shear of one kind or another is required. Of course, the accuracy of the cuts needed is less than in the case of flying shears previously discussed.

There are several types of shears built for this purpose, and no attempt will be made to cover all of them in this review.

One type, designed by Norman Rendelman, consists essentially of two knives rotating toward each other, set at an angle to the line of bar's travel and run at about the bar's speed. (See Fig. 20.) The bar passes in a trough just outside the reach of the knives. When the front end of a bar hits a flag on the shear runout table, a special motor or a solenoid moves a part of the trough with the bars sideways, and quickly flips the bar across the face of the knives. The mechanism then raises the top knife and lets the trough bring the freshly run-in portion of the bar back into the original position, ready for the next signal to make a cut. It is understood that the travel of the trough back and forth does not take more than 2 seconds; with a delivery speed of say 1800 fpm., the shear can cut lengths of 60 ft., or more. This shear is used extensively and successfully on many merchant mills. The accuracy of the cuts depends on the consistency of the time intervals required each time by the trough mechanism to start from rest, and to complete its travel toward the knives.

The knives, driven by a separate motor, run at a steady speed. Thus no intricate problems are involved in selecting a suitable drive. An adjustable speed d-c. motor fully meets the requirements.

Then, there are shears, built on the "start-stop" principle. In other words, the bar passes between the rotary knives, set apart and at standstill; at the proper instant, a signal is given, the shear motor starts, brings the knives to full speed (approximately corresponding to the metal speed), the knives make a cut and then return to their original position. Three types of such "parting" shear are schematically shown on the Fig. 21. The sketch (a) represents a "knife and anvil" shear, built by United Engineering & Foundry Co. The lower drum or "anvil" is driven by continuously running d-c. motor; the speed is adjusted in correspondence with the delivery speed. The upper shear element consists of a rotating knife K, which is set at standstill at some position A, and is driven by a direct-connected mill type d-c. motor. When the front end of the bar strikes a flag on the shear runout table the shear motor starts and rotates the knife K in the direction of the arrow. By the time the knife is in the cutting position B its speed is approximately equal to, or is somewhat higher than, the metal speed, and the cut is made. Right after this, the shear motor is plugged, by reversing the armature circuit and inserting in it an additional plugging resistor; the plugging is applied by a limit switch suitably geared to the shear. The knife finally stops at some point C; the plugging resistor is then short circuited, and the motor reverses and accelerates in the counter-clockwise direction.

At a proper point of the return travel dynamic braking is applied, and the motor drifts back to position A, where it comes to rest against a stop; see sketch "e", Fig. 21. (This stop is not effective for the clockwise direction of rotation.) The reasons for selecting this rather unusual type of movement will be later explained.

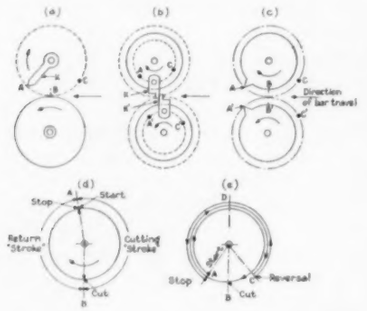

FIG. 21—Principle of operation of electrically driven "parting" shears cutting bars to cooling bed lengths. (a)—"Knife-and-anvil" shear (see Fig. 22); (b)—"Front End" shear; (c)—Rotary Shear; (see Fig. 24) (d)—Non-reversing cutting cycle; (e)—Reversing Cycle.

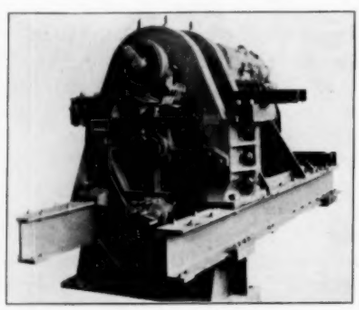

FIG. 22—Shop View of "Knife-and-Anvil" Flying Shear manufactured by United Engineering & Foundry Co. for cutting small bars to cooling bed length. Maximum strip speed—3000 ft. per min. Performance—see Fig. 23.

In one known case a similar shear was equipped with a 12 hp.—700 rpm.—230 volt mill type motor. The shear is designed for cutting flat material up to ¼" thick, to cooling bed lengths, for a maximum delivery speed (for light sections) up to 3000 fpm.

Fig. 22 illustrates such shear. Fig. 23 is a reproduction of an oscillogram showing the shear performance.

Another similar shear, but of a heavier type, also manufactured by the U. E. & F. Co. is shown on the sketch (b). The two knives, K and K, are carried by the upper and lower drums or cranks, respec-

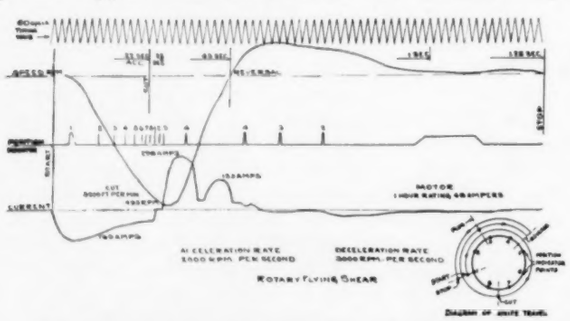

FIG. 23—Oscillographic Record of performance of the "Knife-and-Anvil" Flying Shear, similar to Fig 22.

tively; both knives can slide up and down in a common vertical guide, (not shown) which is permitted to travel horizontally, when the shear drums rotate. Both drums are geared together and are driven jointly by a motor, through a suitable speed reducer.

At standstill the knives are set at some position A-A¹. At the proper time the shear starts and the knives are accelerated to the required speed by the time the knives come to the cutting position (as shown on the sketch); the motor is then plugged, the knives travel to position C-C_1, stop, and then are brought back to the original position A-A_1.

Sketch (c) illustrates a Mesta rotary shear, quite similar in design to the flying shears previously discussed at length in this paper. Both drums, each carrying a knife, are geared together and are driven by a common geared motor. In case of one known shear of this type installed at a 14" Merchant Mill a 75 hp.—500/1000 rpm.—230 volt mill type d-c. motor was selected, geared to the drums in a ratio of slightly less than 4:1. The mill delivery speed ranges from 625 to 1250 fpm. The kinematics of this shear are quite similar to those of the other parting shears, (a) and (b); i.e., the knives travel in the direction of the arrow from their standstill position A-A¹ to the cutting position B-B¹; the motor is then plugged, the knives are stopped and reversed at C-C¹ and are then returned to the original point A-A¹. Fig. 24 illustrates the construction of this shear.

The reasons why the knives of these shears travel in a rather peculiar way after each cut will be presently explained.

Generally speaking, it is conceivable to arrange such a shear drive of a non-reversing type. Suppose, see sketch (d), Fig. 21, that the knife is in the position A, when at standstill; the knife will be then accelerated to the full speed by the time it reaches the cutting position B; it should be then retarded and brought to standstill in the initial position A. The difficulty lies in obtaining enough torque to accelerate to full speed and then to stop the rotating parts in the limited space available for the "cutting" and

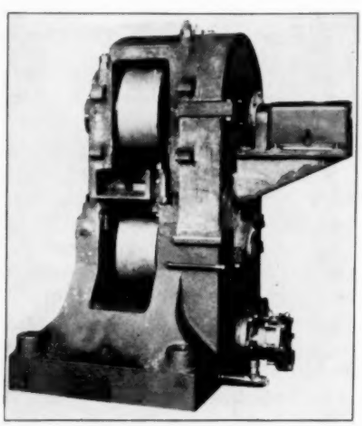

FIG. 24—Shop View of the Mesta Flying Shear used for cutting merchant bars to cooling bed length. Shear driven by a 75 HP. D.C. motor, coupled to right-hand end of the lower shaft. Limit switch connected to the upper drum stops the shear in its initial position after each cut.

for the "return" strokes; in other words, the shear might not be fully up to the needed speed while cutting; then it might overtravel the stopping point, —leaving still less space for the next cutting stroke, etc. However, with a moderate mill delivery speed and with an oversized driving motor it is feasible to design and to operate a shear drive on this principle.

For higher delivery speeds and with motors of normal capacity, the knife travel, described previously, and shown diagrammatically on sketch (e), Fig. 21, is usually found advantageous, as it nearly

doubles the available space within which the shear might be brought to full speed.

In selecting the electric drive and its control, the limiting condition is that of the maximum delivery speed; i.e., the motor should then successfully accelerate the shear to the maximum knife speed in the prescribed space of travel. Now suppose the mill delivery speed is reduced; the operator may then wish to reduce the maximum speed of the knives; the control should permit him to do so.

There are several ways of doing so. The value of the starting resistor may be adjusted; the timing between the accelerating steps may be altered; or any other suitable method may be applied. The control of the maximum knife speed is usually centralized in a multi-point master switch or controller, and the operator adjusts this speed, watching the shear performance.

The length of cut is determined by the location of the flag switch, on the runout table, which is deflected by the approaching end of the bar. This switch initiates the starting of the shear from standstill; as the accelerating time does not change perceptibly from bar to bar, the stock is cut into uniform lengths, to suit the cooling bed, with an accuracy of a few inches.

Instead of moving the flag switch alongside the runout table, for different lengths of cut, the switch may be left in a fixed position at the end of the table nearest to the shear. An adjustable timing relay can then be interposed between the functioning of the flag switch and the starting of the shear; in this manner the cut length can be varied. An accurate, consistent timing device is, of course, required for best results; such electrical devices are available.

After the cut is made, a geared limit switch, suitably connected to the drums, assumes control of retarding and stopping of the shear, in the manner previously described.

CONCLUSION

We have briefly reviewed in this paper a few of the several types of electrical equipments built for driving flying shears. The actual experience with these and with other drives permits us to draw the following conclusions:

1. The problem of cropping the front end of each bar delivered at the mill speed has been quite successfully solved.
2. An ideal accuracy of regular cuts can be obtained only if an absolutely synchronous tie, mechanical or electrical, can be devised between the mill and the shear. This tie should be of an adjustable ratio, but rigid after an adjustment is made. A good solution for all cases has not been found as yet.
3. A mechanical tie between the mill and the shear can be provided in a shape of a gear box, cone pulleys, Reeves drive, hydraulic transmission, or like. With the exception of the gear transmission, the other drives are limited as to the speed and power transmitted; neither are they 100% accurate in maintaining the ratio. The gear transmission answers the requirements fully, but is very expensive and bulky when the amount of transmitted power is appreciable, and when fine steps of adjustment are required.
4. An electrical tie between a d-c. shear motor drive and a mill is only an approximation of the right solution. The speed ratio regulators available for holding the ratio constant are not 100% perfect; not all of them combine these essential qualities, sensitivity and quickness of action; only this combination can make them accurate. Even the best regulator responds to a change only after it has taken place; it has to act through a magnetic field of an electrical machine. Time lag between a "distortion" and "correction" is unavoidable. It should be remembered that any claim made for the regulator should be substantiated by actual measurements at the bar piler.
5. A d-c. shear drive, synchronized with the delivery speed by means of a speed ratio regulator, although not an ideal solution, is satisfactory, from practical standpoint, for shearing on the fly of such semi-finished products as sheet bars, billets or skelp. Such equipments perform fully as good as the steam flying shears. Electric drives have justified themselves in these cases from engineering and economic standpoints. They will be, undoubtedly, widely used in the future.
6. For shearing a finished product, such as strip, at a mill delivery speed and with such accuracy as 1/8" or 1/16", a d-c. drive with any speed regulator is not adequate. A mechanical transmission between the shear and the metal driving rolls remains as yet the only possible solution.
7. An ideal shear drive requires a motor, not yet invented nor reduced to practice: a synchronous motor, electrically connected to the mill and having an infinite number of adjustable speeds. Only the future will tell whether such a motor will be designed and built.

Discussion

Presented by

JOHN C. REED
Electrical Engineer, Bethlehem Steel Co., Steelton, Pa.

It seems to be a tradition that John Reed must always be called on to make some remarks before the Philadelphia Section of the Association of Iron and Steel Electrical Engineers in the way of a discussion—whether or not John Reed knows anything about the subject under discussion.

When this subject was discussed before our Papers Committee, the thought was that it was to be a paper on motor driven shears. Now up at the Steelton Plant we haven't got any flying shears and I never thought about a flying shear. I came down here tonight to learn about a great big motor-driven shear that would cut off 8x8 blooms and all that kind of thing. Well, I have been amply repaid for the trip, regardless of the fact that I haven't learned anything about a shear to cut off these 8x8 or 10x10 blooms; and it has been more or less of a revelation to me the way these very intricate problems have been worked out. To be sure, I have read some articles on the subject—down to about the second page, anyway, when I would usually stop—but it was very pleasing and very interesting and entertaining to be able to sit here and listen to Mr.

Umansky's very clear and vivid descriptions of these things without having to go through the mental effort, which you have to exert when you try to dig it out of a technical paper.

However, to get back to my motor-driven blooming shear, I have had that in my mind for many years. When I first broke into the steel game, about twenty-nine years ago, that's the kind of an animal we had then: it was a big flywheel-driven shear with a clutch on it and the thing worked, sometimes, when the clutch didn't fail, but it did shear the blooms. It seemed, however, that that type of shear went out of fashion about twenty years ago and it seemed to be the style to put in a hydraulic shear with a steam intensifier and apparatus of that kind and, so far as I know, the style hasn't changed a great deal yet. The Tod Company did build a motor-driven shear of considerable capacity for shearing billets, that is a number of billets in multiple, such a shear having been installed at the Edgar Thompson plant probably fifteen or eighteen years ago, I think. They were rolling billets in a rail mill and would saw them off at rail lengths, or approximately that, and when they had a whole row of them they would slide them up together and shear off six, eight or ten of these billets at one clip with this motor-driven shear. That worked first-rate but I never heard of anybody making a larger one for shearing off 8 or 10-inch blooms.

Now that shear worked from a 300 or 400 H.P. motor, that started and stopped for every stroke of the shear and seemed to work beautifully for the job for which it was designed. But there has been no improvement, so far as I know, in the way of a strictly motor-driven piece of machinery to take the place of the combination steam-hydraulic shears. A prominent German engineering company have gotten away from the steam end of it I believe, by installing a number of high pressure steel tanks, somewhat similar to the cracking tanks used in making gasoline, which are capable of standing very high pressures, which are partly filled with water and partly filled with air and the water is pumped into these tanks and the air furnishes the force to push the water through the hydraulic shear, or forging press as the case may be, but it doesn't get away from the high pressure valves which are required in such a case, and while they claim that their valve is perfect, I have my doubts; also the pump, because a high pressure hydraulic pump is anything but a thing which would stir up a Christmas spirit, so that we are still lacking something in the way of a fully electrified rolling mill, there is still a piece of apparatus there which ought to be electrified. Now, I had so much faith that this would happen that in 1920 when I installed a reversing blooming mill drive, I insisted that there be a shaft extension on the end of the flywheel motor for another generator and that generator was going to drive the motor on the shear that I intended to put out there, fourteen years ago. Well, the shaft extension is still there, but the old hydraulic shear is still there also.

Now, I have been waiting for somebody to bring out such a shear; that is, a purely electro-mechanical shear which will do everything a hydraulic shear will do, enable the operator to lower the blade of the shear down on the bloom or slab and be able to stop it there and then, if he finds he is O.K. for length, to apply the power and shear it off. I had hoped to learn something about such a piece of apparatus this evening and probably Mr. Umansky, or somebody else present, will be able to tell us something about the latest developments, or what is being thought about along this line.

▲

Discussion

Presented by

L. A. UMANSKY
Industrial Engineering Dept., General Electric Company, Schenectady, N. Y.

I believe that all that Mr. Reed requires to electrify his shear is to purchase the generator for which he had provided space on his M-G. set, and the d-c. motor for driving the shear. These machines and a suitable control will readily do the trick. As a matter of fact, there are several electrically driven bloom shears which are in successful operation for a number of years. I will describe but one of these installations to illustrate the point.

An 800-ton bloom and slab shear is installed at the Great Lakes Steel Corporation's plant at Detroit, Mich. This shear is suitable for cutting slabs up to 8x25", or three 8x8 blooms set side by side. The shear is of the crank type and starts and stops for each cut. There is no flywheel on this shear, and there is no clutch between the driving motors and the shear itself.

The shear is capable of making fourteen cuts a minute, starting and stopping for each cut, provided of course that the shear would start at once after it has been brought to a final stop after the preceding cut. No shear, of course, operates in this manner, but the above figure (14 possible cuts a minute) points out that each cut can be made in approximately 4.5 seconds, from start to finish. This shear is driven by two mill type motors, each rated 200 hp.—230 volts, built in frame MD-420. These motors are connected in multiple and operate from 230 volt mill supply, magnetic control being used for starting and stopping.

While this shear is, as far as I know, the largest motor-driven start-stop bloom or slab shear in the U. S. A., it is not by any means the largest in the world. Electrically driven shears of this kind were built in Germany for 1700 tons, or maybe larger. Some of these shears are of the crank type, as the one at Detroit, while some others are of the reciprocating type with the length of stock being adjusted to suit the size of bloom or slab to be sheared. The latter type of shears require, of course, a reversing type of control and this can be readily provided electrically.

The power for driving the shear motors may be taken either from the general d-c. supply of the steel plant, or from a separate generator especially provided for. In the latter case, Ward-Leonard type of control can be advantageously used. The control equipment should be carefully laid out, but the difficulties involved are really negligible if you compare this problem with that of the flying shear control.

ITEMS OF INTEREST

PERSONNEL CHANGES

Samuel E. Hackett, vice president in charge of sales, Jones & Laughlin Steel Corporation, has been elected president of the company as of June 1, to succeed George Gordon Crawford, who has resigned from that office as of May 31.

Mr. Crawford will continue as a director and a member of the executive committee, and will also serve in an advisory and consulting capacity.

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L. S. Hamaker, sales promotion manager of the Republic Steel Corporation, Youngstown, O., has been appointed vice president and general manager of the Berger Mfg. Co., Canton, O., a division of Republic.

Joseph B. Montgomery, associated with the Berger company since 1919, has resigned as vice president and general manager, a position held since 1930.

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R. S. Archer has been appointed chief metallurgist of the Chicago district of the Republic Steel Corporation, Youngstown, O. He has been director of metallurgy for the A. O. Smith Corporation, Milwaukee, and prior to that was in charge of the Cleveland section of the Aluminum Research Laboratories, Aluminum Company of America.

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Five vice presidents and one commercial vice president were elected by the board of directors of the General Electric Company at the meeting on May 25 in New York City.

J. E. Kewley of Cleveland was elected a vice president in general charge of the incandescent lamp department.

R. C. Muir of Schenectady was elected a vice president in charge of the engineering department.

C. E. Tullar of Schenectady was elected a vice president in charge of the patent department.

E. O. Shreve of Schenectady was elected a vice president in association with Vice President J. G. Barry, in the commercial activities of the apparatus and supply business of the company.

H. L. Andrews of Erie was elected a vice president in charge of the activities connected with the electrification of steam railroads and such other duties as may be assigned to him by the president.

W. O. Batchelder of Chicago was elected a commercial vice president in charge of the commercial activities of the Chicago district.

T. W. Frech asked to be relieved of his responsibility as vice president in charge of the incandescent lamp department. "The company, in acceding to his request," President Gerard Swope said, "recognizes with appreciation his many years of devoted service, and is glad to make the announcement that he will remain with us in an advisory capacity and continue to give much of his time to our lamp development problems, in which he has always been greatly interested, and such other problems as we may wish to place before him."

Charles W. Dean, who for the last five years has been associated with the Cleveland office of Crocker-Wheeler Electric Mfg. Co., has been made district manager. Mr. Dean is a graduate electrical engineer of Cornell University and is very well equipped to serve in his new capacity.

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J. S. Murray, well known active member of the A. I. & S. E. E., has just recently been appointed manager of electrical sheet sales for the Follansbee Brothers Company with headquarters at Follansbee, W. Va. These new duties will be in addition to his other activities as chief electrical engineer and special assistant to the metallurgist.

For years, Mr. Murray has specialized in the manufacture, research and application of silicon steel sheets to the Electrical Industry. His contacts in this field have probably made him one of the best known men among the designing engineers of the Electrical Industry. In addition his activities and achievements as chief electrical engineer of the Follansbee Company have earned for him an enviable reputation among steel mill engineers.

He has been an active member of the Association for many years, a member of National Committees of the Association and has contributed many editorials and papers of engineering merit to the Association's Proceedings. One of Mr. Murray's latest papers dealt with changing over his plant which operated on 25 cycle over to 60 cycle without incurring a single delay in operation or any accidents to employees engaged in this work.

▲

Harry L. Meyers has been appointed assistant works manager of the West Leechburg Steel Co., West Leechburg, Pa. He has been associated with the company for 19 years, and was formerly night superintendent, and most recently hot mill superintendent. R. C. Gray, who has been connected with the company for 25 years, has been promoted from the position of night superintendent to that of superintendent of the hot mills. Irvine Shoff, formerly chief inspector, has been appointed night superintendent. Elby Coy, formerly assistant cold mill superintendent, has been made chief inspector.

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Edward C. Gainsborg has been appointed general manager of the Roller Bearing Company of America, Trenton, N. J. Mr. Gainsborg was formerly associated with the company in the capacity of sales manager for a period of several years.

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B. J. Cross, who from 1921 to 1931 was associated with the engineering activities of Combustion Engineering Corporation, rejoined the engineering department of the present organization, Combustion Engineering Company, Inc., on May 1. He will be engaged in development and research work under the direction of John Van Brunt, vice president in charge of engineering, and of Henry Kreisinger.

(Please turn to page 244)

OFFICIAL RULES AND REGULATIONS

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS

IRON AND STEEL EXPOSITION

CLEVELAND PUBLIC AUDITORIUM, SEPTEMBER 18, 19, 20, 1934, CLEVELAND, OHIO.

1—APPLICATION FOR SPACE: Applicants must use the official application form.

2—COST OF SPACE: The cost of space is shown on separate attached sheet. This cost includes the rental of the booth for the period shown, construction of backwall, posts and side rails and a uniform sign for each booth, general decorations, general janitor and general watchman services. Removal, storage, and redelivery of empty cases, etc. The Management will not be responsible for lost, damaged, or destroyed cases, etc. Each empty case, crate, etc., must be plainly tagged with the Exhibitor's name and booth numbers. Tags can be secured from the Floor Manager's office. Untagged cases, crates, etc., will be considered as discards by the Management and so destroyed.

Any and all spaces, all booths and general layout as shown on official floor plans, are subject to modification, alteration or removal at the discretion of the Management.

3—PAYMENTS: All manufacturers, dealers or individuals desiring the privilege of exhibiting or soliciting business at this Exposition will be required to pay the full price of space they use, as shown on the official price list, on or before Saturday, September 1st, 1934. Exhibitor's failure to meet these requirements forfeits the advance payment and all rights as an exhibitor in above described Exposition.

The exhibitor shall pay all charges incurred in connection with drayage, freight and express shipments, installing and dismantling of exhibits where help is engaged, floral, sign, photographic work, etc., on or before Thursday, September 20th, 1934, 4 P. M. (All charges other than those collected by the Auditorium officials.)

Manufacturers or their representatives, not renting exhibit space in the Iron & Steel Exposition, **will not be permitted** to solicit business, nor make any business contacts, neither on the floor of the Iron & Steel Exposition, nor about the building, or adjacent grounds.

All contracting exhibitors are held strictly responsible for and must pay all bills charged against their space; any divisions of bills must be cared for by the individual exhibitor signing our official contract for space. All charges for services will be invoiced against each booth holder only.

Exhibitors showing lines in addition to those of their own manufacture must advise the Iron & Steel Exposition Management at their Pittsburgh, Pa., address by August 20th, 1934, the full name and address of such firms, together with information as to type of lines to be shown in such cases, in order that these firm names may also be listed in our Iron & Steel Exposition Directory at the time of the Exposition, also that they may be included in our September Convention issue of the Iron & Steel Engineer which will also be used at the Exposition as a directory. This information further facilitates the delivery of telegrams, telephone calls, mail, express and freight shipments, etc., and avoids delay in direction of guests desiring to visit such exhibits.

All out-going charges must be prepaid. NO ADJUSTMENTS WILL BE MADE ON ANY BILL AFTER 4 P. M., THURSDAY, SEPTEMBER 20th, 1934. All claims, or questioned charges, must be settled prior to aforestated time and date.

4—SUB-LETTING OF ANY SPACE: No exhibitor shall assign, sub-let, or portion the whole, or any part of the space allotted without the full knowledge and consent of the Management of the Iron & Steel Exposition.

5—RESTRICTIONS: The Iron & Steel Exposition Management reserves the right to restrict exhibits which, because of noise or for any other reason, might be objectionable; also to prohibit any exhibit which, in their judgment, might detract from the general character of the exhibit or the Exposition as a whole. This restriction includes persons, things, printed matter, or anything of the character which might be objectionable to the Exposition as a whole. Noisy exhibits, which have been passed upon by the Exposition Management, must not be operated except for actual demonstration to interested prospects and then for short periods only and spaced as far as possible apart in such operations.

Exhibitors desiring to build unique, or elaborate installations, are encouraged to do so but only in such locations where such installations do not interfere with the rights and comforts of other exhibitors, or does not become a detriment to the Exposition as a whole. Complete plans for all such installations must be submitted in advance to the Management of the Exposition for their approval and prior to the start of building such exhibits.

The use of bunting, crepe paper, artificial flowers or other inflammable material will not be permitted unless flameproof.

Exhibitors requiring compressed air, gas, water, drains, steam, telephones, etc., services, must select booth locations adjacent to stations of such services where such connections are available and as shown on the official floor plan of the Exposition.

6—RESPONSIBILITY: Exhibitors must make provision for the safekeeping of their goods, merchandise, etc., before, during, and after the close of the Exposition. The Iron & Steel Exposition Management will furnish **general** watchman service day and night, but at no time accepts responsibility for the safe-keeping of any exhibits, goods, or merchandise, etc.

Neither the Association of Iron & Steel Electrical Engineers, nor the Iron & Steel Exposition Management will be responsible for any loss or damage to goods or exhibit material consigned to their care, nor will they be responsible before, during, or after the close of the Iron & Steel Exposition for such materials, goods, exhibit material, etc.

Exhibitors, or their authorized representatives, should superintend the unpacking, erection, dismantling, and repacking of their exhibit material to insure safety to such materials, goods or exhibits.

Efficient help will be supplied by the Exposition Management, at a nominal rate, to assist the exhibitor in moving, unpacking, erecting, dismantling and repacking, etc., of exhibit materials.

Neither the Exposition Management, the Association of Iron & Steel Electrical Engineers, nor the officials of the Cleveland Public Auditorium shall be responsible for any injury, damage, etc., that may occur to any exhibitor, or his employees, or his representatives, nor as to the safety of any exhibit, materials, property, etc., against robbery, fire, accident, or any other destructive cause.

Exhibitor shall pay and save the Association of Iron and Steel Electrical Engineers and the Iron & Steel Exposition Management, harmless from any and all damages, loss or liability of any kind whatsoever occasioned within said Exposition Hall or upon the premises adjacent thereto, by reason of any injury to person or property occasioned by any act or omission, neglect or wrong doing of the exhibitors or any of its representatives or agents to invitees, employees or other persons admitted by the Association of Iron and Steel Electrical Engineers or the Iron and Steel Exposition Management upon the premises and said exhibitor will at its own cost and expense defend and protect said Association of Iron and Steel Electrical Engineers and the Iron and Steel Exposition Management against any and all such claims or demands.

Exhibitors will be held responsible for acts of their own or their representatives or employees, that shall result in damage to the Cleveland Public Auditorium, the permanent fixtures thereof, the property and equipment of the Iron & Steel Exposition or that of the Agents of the Iron & Steel Exposition.

If insurance or additional protection of any kind is desired by the exhibitor, it must be obtained by the individual exhibitor, subject to the advance approval of the Iron & Steel Exposition Management.

7—REGISTRATION OF EXHIBITORS, EMPLOYEES, AGENTS, ETC. Each exhibitor, each of his employees, or agent upon arrival at the Exposition Hall of Cleveland Public Auditorium must register at the Floor Manager's office and receive his Exposition pass in order to have free access to Exposition Hall, etc. Each exhibitor or his authorized representative, MUST IMMEDIATELY ENTER AND SIGN AN ORDER WITH THE CLEVELAND PUBLIC AUDITORIUM OFFICIALS FOR ALL HIS WORK, and **then and there to receive the invoice and make the proper cash settlement with the Auditorium officials.** The advance information received from the exhibitor is passed on to the Auditorium officials by the Iron & Steel Exposition Management BUT THIS IS NOT CONSIDERED AN OFFICIAL ORDER by the Auditorium officials but serves as a guide only in the preliminary preparations for power, etc., to be supplied throughout the Exposition.

An Exhibitors' Service Station will be maintained by the Auditorium officials in the Floor Manager's Office and this Station will be open daily from 8:30 A. M. to 6 P. M. during the installation of the exhibits, also during the hours of the Exposition for the purpose of giving information and aid to the exhibitors and to co-operate with the Exposition Management in solving any difficulties that might arise at any time.

8—ARRANGEMENTS OF EXHIBITS: Exhibitors will arrange their exhibits so as not to obstruct the general view, nor to hide other exhibits. No partitions other than those supplied in the general set-up will be allowed unless approved in advance by the Iron & Steel Exposition Management.

9—BOOTH SIGNS: Uniform booth signs, bearing the name of the exhibitor who contracted the space, will be provided and installed by the Management. No other signs will be permitted above the bottom line of this booth sign, nor can any sign be suspended from this booth sign. Large cloth, or canvas display signs will not be permitted to be used, however smaller card signs may be used on their individual displays or larger signs can be used that will fit within the size of the booth-back as supplied in the standard booth set-up.

10—INSTALLATION OF EXHIBITS: This work may be started on Friday, September 14, 1934, at 9 A. M., and must be completed in full by 1:30 P. M., Tuesday, September 18, 1934, with all debris, boxes, crates, etc., removed from off and about the space and be ready for the official opening at this time.

(Double time applies for skilled labor for overtime after 4:30 P. M. and all day Saturday and Sunday.)

11—DISMANTLING OF EXHIBITS: The exhibitor agrees not to dismantle in any way whatsoever nor in any way disturb his exhibit, nor to do any packing of any kind prior to the final signal indicating the official closing of the Exposition.

Each exhibitor agrees to complete his dismantling and to have all packing of same completed and to have the exhibit material removed from the floor of the hall by 6 P. M., Sunday, September 23rd, 1934; any exhibit material left in the Auditorium will be placed in storage at the expense of the exhibitor.

It is further agreed that neither the exhibitor, nor any of his representatives or agents will not take from the floor of the Exposition at any time any material or package of any kind without the written consent of the Floor Manager—this is a protection to each exhibitor and his exhibit material.

12—HOURS OF THE IRON & STEEL EXPOSITION: **Officially opens at 1:30 P. M., Tuesday, September 18th, 1934.**

Tuesday, September 18, 1934—Opens at 1:30 P. M., to 5:30 P. M., also 7 P. M., to 10 P. M.

Wednesday, September 19, 1934 } Open from 10 A. M. to 10 P. M.
Thursday, September 20, 1934 }

13—SPECIAL ADVANCE SERVICE NOTICE: Those exhibitors desiring special services such as compressed air, steam, water, telephone, large blocks of electric power or special electric service of any kind, must give advance notice to the Management of the Exposition at least 45 days in advance of the opening date of the Exposition.

14—SKILLED LABOR will be supplied by the Management at the request of the exhibitor at standard rates prevailing in Cleveland, O., at the time our Exposition is held.

15—EARLY SHIPMENTS are requested from the exhibitors of their material in order that there may not be any delay in getting the Exposition fully set-up in advance of the hour of opening.

16—THE IRON & STEEL ENGINEER, the Association of Iron & Steel Electrical Engineers monthly publication, will be the only official periodical of the Convention and Iron & Steel Exposition. The September issue will be the Convention and Exposition number and will be devoted to the Convention and Iron & Steel Exposition activities.

OFFICIAL APPLICATION FOR SPACE

IRON & STEEL EXPOSITION

Sponsored, owned and controlled by

Association of Iron and Steel Electrical Engineers

CLEVELAND PUBLIC AUDITORIUM, CLEVELAND, O.

September 18, 19, 20, 1934

IRON & STEEL EXPOSITION,
1010 Empire Building,
Pittsburgh, Penna.

Gentlemen:

In accordance with, and subject to, the Rules and Regulations governing this Exhibit, the undersigned hereby makes application for space at the Iron and Steel Exposition, to be held in conjunction with the Thirtieth Convention of the Association of Iron and Steel Electrical Engineers, at Cleveland Public Auditorium, Cleveland, O., September 18, 19, 20, 1934.

Our preferences of location, as shown on the official floor plan, are as follows:

First Choice No..... Second Choice No..... Third Choice No.....

Price $..... Price $..... Price $.....

The following is a general statement of the character of the proposed exhibit:

Class of apparatus .....

Approximate size .....

Approximate weight .....

Electrical requirements will be: .....

.....

Gas, compressed air, water, or general requirements will be: .....

FIRM NAME .....

Signed by .....

Title .....

Address .....

Date of application .....

All correspondence with respect to exhibit shall be addressed to Mr. .....

It is mutually understood that the Exhibitor, in signing this agreement will adhere to, and abide by, our Rules and Regulations as herewith attached.

In the interests of the individual exhibitor, and the Exposition as a whole, the exhibits will be classified, and the assignments made after the Management has full knowledge of the character of the proposed exhibits and the exhibitors' requirements.

CHECK FOR $25.00 MUST ACCOMPANY THE APPLICATION FOR SPACE, which amount paid will be credited as part payment of the booth space. In case of cancellation this amount paid will not be refunded. The balance due on the booth space must be paid in full on or before Saturday, September 1st, 1934, or the space reserved by the exhibitor may be declared vacant by the Management, and the deposit forfeited. All applications for space received on or after September 1st, 1934 must be accompanied by check in full payment of the booth space.

NOTE—This agreement is contingent upon strikes, fires, or occurrences beyond the control of mankind.

(Continued from page 241)

Prior to 1921 Mr. Cross was with the U. S. Bureau of Mines and was identified with a number of notable investigations on the burning of fuels.

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Charles R. Hook, president of The American Rolling Mill Company, announced that S. R. Rectanus, vice president in charge of operations, has asked to be relieved of his duties as Armco's operating head to establish himself as consultant on management problems, particularly those concerning organization and industrial relations.

Mr. Rectanus has been in Washington for several weeks in the interests of The Durable Goods Industries Committee in its studies of the recovery program and the preparation of a report being made to President Roosevelt at the request of General Johnson. He has agreed to remain at the Mayflower Hotel in Washington for the time being in connection with the activities of the sub-committee on Industrial Relations, of which Mr. Hook is chairman.

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Closely identified with the welding industry for the last seven years, Seth H. Taylor, Jr., has been appointed Pacific Coast manager for The Lincoln Electric Company, Cleveland, O. Mr. Taylor will make his headquarters at San Francisco.

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WITH THE MANUFACTURERS

The Surface Combustion Corporation, Toledo, O., announce the following steel mill installations:

At the Continental Steel Company, Kokomo, Ind., there is being installed a galvanizing furnace which is equipped with oil gasification firing equipment. Also, at the same plant, there is being installed a continuous walking beam pack furnace of the double row design. The Steel Company of Canada is installing a Surface Combustion walking beam normalizing furnace for sheets. The Bethlehem Steel Company, at Sparrows Point, have just put in operation a Surface Combustion walking beam pair furnace for use in heating pairs for a 3-high mill. The Granite City Steel Company is installing a Surface Combustion walking beam furnace for heating pairs before making tin-plate breakdowns. Also, two Surface Combustion walking beam pack furnaces for finishing tin-plate. The Youngstown Sheet & Tube Company recently contracted with Surface Combustion Corporation for a four-hole soaking pit.

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The Allis Chalmers Manufacturing Company, Milwaukee, Wis., is distributing their new leaflet No. 2173 on Squirrel Cage Induction Motors, Type "AR". Copy of this leaflet may be obtained by writing the above company.

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The new catalog on Bantam Tapered Roller Bearings just published combines conciseness with a very thorough treatment of load carrying capacities and other pertinent information on Tapered Roller Bearings. Every effort was made to give complete and accurate information on true load carrying capacities without confusing the issue with complicated and long drawn out calculations. This catalog may be secured by addressing the Bantam Ball Bearing Co. at South Bend, Ind.

▲

The Chicago, Milwaukee, St. Paul & Pacific Railroad has just placed an order with The Timken Roller Bearing Company, Canton, O., for bearings and boxes for 50 de luxe passenger coaches which this railroad will build in their Milwaukee shops. Two of these sample de luxe cars have been constructed and one of them will be on exhibition at The Century of Progress, Chicago. It will be recalled that the Milwaukee Road was the first to use roller bearings on their transcontinental trains. This road equipped their "Olympian" train between Chicago and Seattle and their "Pioneer Limited" between Chicago and St. Paul-Minneapolis in 1927. A total of 157 cars, including 72 Pullman cars, were equipped with Timken Bearings in 1927 and some of these cars have made 1,500,000 miles to date.

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OBITUARIES

Taylor Allderdice, formerly president of the National Tube Company, Pittsburgh, died at his home there on May 20, aged 71 years. Prior to his resignation in December, 1928, he had held the presidency of that company since April, 1926, following the retirement of William B. Schiller, having served as vice president in charge of operations since 1902.

▲

Fred C. Eckworth, Cleveland manager of the Crocker-Wheeler Electric Manufacturing Company, passed away at a hospital in Cleveland, O., on June 1. Mr. Eckworth was 49 years of age. He had been a member of the Crocker-Wheeler sales force for eighteen years, nine of which he was the Cleveland manager for the company. He had a host of friends throughout the Cleveland district, especially in the Iron and Steel industries. He was an associate member of the A. I. & S. E. E., and the membership extend their sympathies to the associates, friends and family of this well known engineer.

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Benjamin Franklin Mohr, who retired in October, 1932, as assistant to the president of the Illinois Steel Company, died May 26 at his home in Evanston, Ill.

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William C. Cronemeyer, aged 86, veteran tin plate producer and known as "the father of the tin plate industry," died at a hospital in McKeesport, Pa., May 22. Born in Germany in 1847, he came to the United States in 1869 and organized the United States Iron & Tin Plate Co., serving as president, general manager and secretary until the company was absorbed by the American Tin Plate Co. He retired about 20 years ago.

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Edward M. Hewlett, aged 68, veteran engineer of the General Electric Company who retired from active service in 1931, died at his home in Schenectady May 24 after an illness of a few days.